WRD RESOURCE ROOM PECO

WATER RESOURCE MANAGEMENT PLAN

1995

NATIONAL PARK SERVICE
U.S DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE
WATER RESOURCES DIVISION
FORT COLLINS, COLORADO
RESOURCE ROOM PROPERTY

WATER RESOURCE MANAGEMENT PLAN

PECOS NATIONAL HISTORICAL PARK

Prepared by

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Pecos National Historical Park
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and

Leadership and Management Training Course
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Superintendent, Pecos National Historical Park Date

NATIONAL PARK SERVICE
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EXECUTIVE SUMMARY

In 1990, Pecos National Historical Park was expanded from approximately 340 acres to more than 6,670 acres with the addition of the Forked Lightning Ranch and sites commemorating the Civil War skirmishes at Glorieta Pass. With the addition of these lands to the National Park System, the park gained responsibility for the management of segments of the Pecos River, Glorieta Creek, and Galisteo Creek containing significant water and aquatic biological resources including a substantial riparian environment. Indeed, these water resources and their water-dependent environments are critical components of both the cultural and natural resource landscapes at the park. The presence and location of a reliable water source was undoubtedly a major factor in the long sequence and pattern of settlement within the region. Land use was further influenced by the Pecos River, which created a small floodplain that offered the opportunity for moderate agricultural activity and produced a stimulus for prehistoric and historic trade (National Park Service, 1993a). In addition, the riparian environments along the Pecos River and Glorieta Creek are a rare resource in the American Southwest and critical to the health and functioning of the park's natural resources. Proper protection and maintenance of these valuable resources is essential to preserving the "multi-theme" history of the park, and its important "gateway" role between the Great Plains and the Rio Grande Valley.

This Water Resource Management Plan has been developed cooperatively by the National Park Service's Water Resources Division, Pecos National Historical Park, and the Albright Training Center to assist park management in the understanding and management of these resources. It provides an overview of existing resource condition, identifies water-related management issues, and develops alternatives addressing water resource issues and management within the expanded park boundary.

Water-related resource issues discussed within this report include:

- water quality management;
- aquatic biological and fisheries management issues;
- the preservation and management of wetland and riparian resources;
- water rights, water quantity, and water supply issues; and,
- erosion/watershed condition concerns.

The Water Resource Management Plan further presents a number of management recommendations and provides seven water-related project statements (Appendix A) that are recommended to provide background information and address foreseeable water-related management issues over the next decade.

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INTRODUCTION

Pecos National Historical Park is a 6,670 acre unit of the National Park System situated in the Pecos River Valley and the foothills of the Sangre de Cristo Mountains, approximately 25 miles southeast of Santa Fe, New Mexico. The park lies close to the terminus of the southern Rocky Mountains and near the entrance to Glorieta Pass, which connects the Rio Grande Valley to the high plains and short-grass prairie of eastern New Mexico (Figure 1).

Water resources and riparian environments are critical components of both the cultural and natural landscapes at Pecos National Historical Park. The presence and location of a reliable water source was undoubtedly a major factor in the long sequence and pattern of settlement within the region. Land use was further influenced by the Pecos River, which created a small floodplain that offered the opportunity for agricultural activity and produced a stimulus for prehistoric and historic trade (National Park Service, 1993a). In addition, the riparian environments along the Pecos River and Glorieta Creek are a rare resource in the American Southwest and critical to the health and functioning of the park's natural resources. Finally, the presence of a reliable and adequate water supply is important to present day park operations.

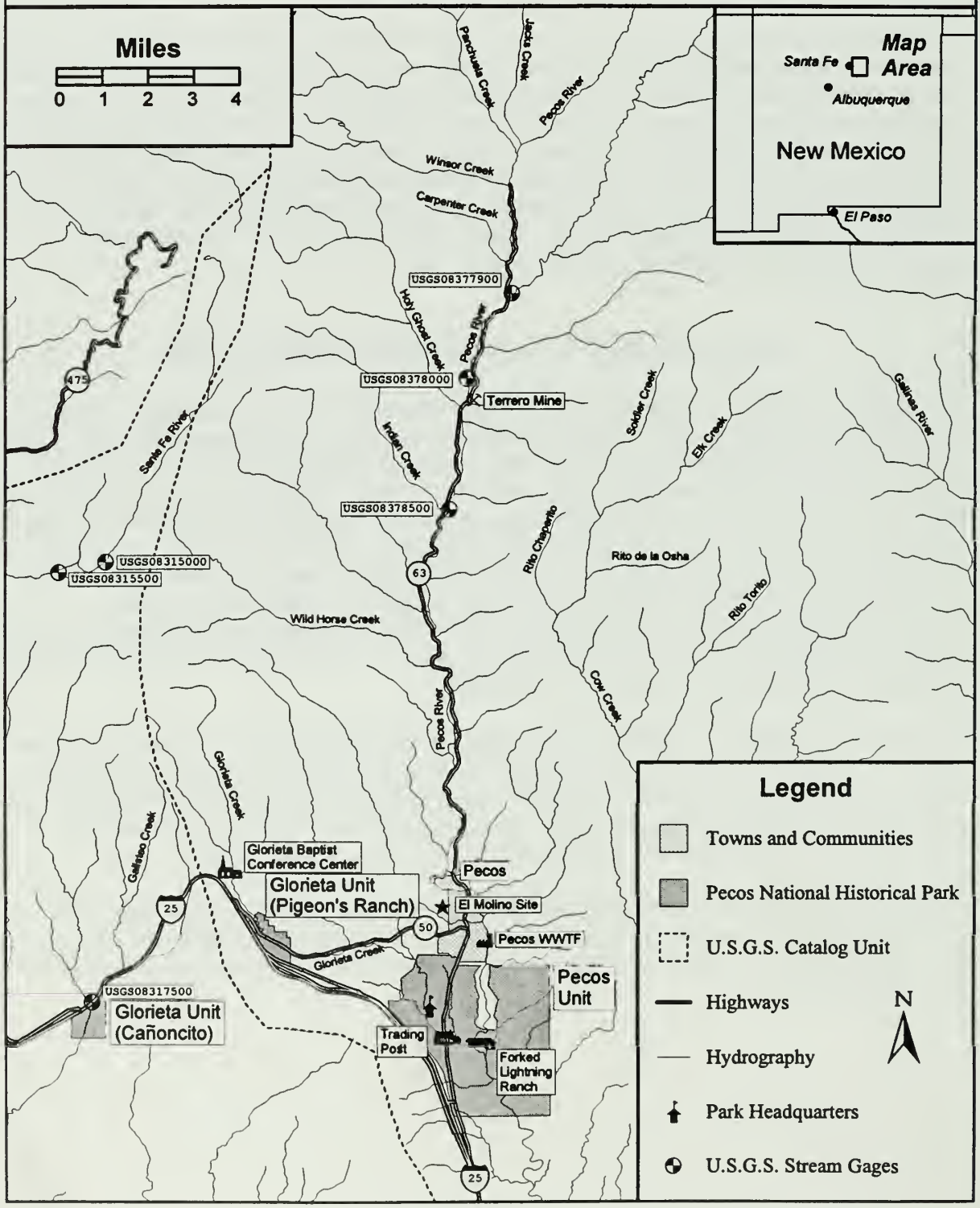
MANAGEMENT GOALS AND OBJECTIVES

The ruins and mission located within Pecos National Historical Park were originally set aside as a New Mexico State Park in 1935. They were added to the National Park System by Public Law 89-54 in 1965, as a 341.3 acre National Monument established to "preserve...a site of exceptional historic and archeological importance,...the seventeenth century Spanish mission and ancient Indian pueblo." In 1990, the unit was expanded to approximately 6,670 acres and redesignated as Pecos National Historical Park. At that time, the initial enabling legislation was repealed and the park's new legislation recognized both the park's "multi-theme history...and its 'gateway' role between the Great Plains and the Rio Grande Valley" and provided for "...the preservation and interpretation of the cultural and natural resources of the Forked Lightning Ranch" (P.L. 101-313). The park was further expanded in late 1990 to add key sites of the Civil War skirmishes known as the Battle of Glorieta Pass to the park (P.L. 101-536).

As a unit of the National Park System, Pecos National Historical Park is also managed under the guidance of the National Park Service Organic Act which requires that the park be operated in a manner "... to conserve the scenery and the natural and historic objects and wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations..." (16 U.S.C. sec 1 et seq.).

Pecos National Historical Park contains two units: the Pecos Unit and the Glorieta Unit. The Pecos Unit includes the original National Monument and the Forked Lightning Ranch addition. The Glorieta Unit, the majority of which remains in private ownership, encompasses the two Civil War battlefield sites.

Figure 1. Pecos National Historical Park and Environs



Objectives relating to the management of water resources at Pecos National Historical Park include:

- acquire appropriate baseline information to adequately understand and manage water-related resources;
- research the history of water use and promote public awareness of the interrelationship between human occupation and the presence of water resources;
- maintain or restore water quality to support the multi-theme history and natural resources of the Pecos area;
- recognize the significance of riparian/wetland resources and manage to preserve their natural function and integrity;
- protect water resources and processes consistent with cultural and historical mandates;
- assure that park development and operations do not adversely affect the park's water resources and water-dependent environments; and,
- promote water conservation through sustainable design and public education.

DESCRIPTION OF WATER AND RELATED RESOURCES

The Pecos River arises in the Sangre de Cristo Mountains at an elevation of approximately 11,000 feet, about 30 miles north of Pecos National Historical Park. The Pecos River is one of the few perennial rivers found in New Mexico. The river flows generally south/southeast for more than 900 miles, eventually emptying into the Rio Grande near Del Rio, Texas.

The Pecos Unit of Pecos National Historical Park contains a 2.9 mile segment of the Pecos River, and the lower 3.2 miles of Glorieta Creek, a perennial tributary to the Pecos River. The Glorieta Unit of Pecos National Historical Park includes a 1.0 mile reach of Glorieta Creek and a 0.5 mile reach of Galisteo Creek.

Varied land-use patterns occur throughout the watersheds of the Pecos National Historical Park's three main waterways (Pecos River, Glorieta Creek, and Galisteo Creek). The upper 13.5 miles of the Pecos River (headwaters to the Pecos Wilderness boundary) is located within the Santa Fe National Forest Pecos Wilderness and is relatively pristine. The water resources below this point (including Glorieta Creek and Galisteo Creek) have been influenced by a number of land-use activities including past mining and milling activities; adjacent streamside development (residential, agricultural, commercial, and corrals); inadequate sewage treatment; illegal dumping; and encroaching sub-urbanization.

The lands within Pecos National Historical Park contain four general vegetative zones including mid-elevation pinon-juniper woodland; artificially created grasslands; cooler, northwest-facing transitional ponderosa pine/Douglas-fir woodland; and a well-watered riparian zone consisting of various cottonwood species and willows (National Park Service, 1993a). The Pecos River and Glorieta Creek both support significant riparian wetlands which provide important habitat for wildlife and migratory birds. In addition, Pecos National Historical Park contains numerous arroyos, at least five springs, four impoundments, and ten wells.

STATE WATER QUALITY STANDARDS

The New Mexico Water Quality Control Commission (20 NMAC 6.1.2213.B) has designated the main stem of the Pecos River from Anton Chico upstream to Alamitos Canyon, and the perennial portion of Glorieta Creek (including those portions of the Pecos River and Glorieta Creek running through Pecos National Historical Park) for use as irrigation water, livestock watering, wildlife habitat, marginal coldwater fishery, and secondary contact recreation. The latter includes any recreational or other water use in which contact with the water may occur and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, wading, and any limited seasonal contact.

Water quality within the Pecos River Basin must be managed in a manner to protect the recognized designated uses for each segment. To protect these beneficial uses, the New Mexico Water Quality Control Commission has developed numeric water quality criteria for a number of water quality constituents including water temperature, dissolved oxygen, pH, fecal coliform bacteria, total dissolved solids, ammonia, chloride, sulfate, chlorine, metals, and

Table 1a. State of New Mexico water quality criteria for the main stem of the Pecos River from Anton Chico upstream to the mouth of Alamitos Canyon (including Pecos National Historical Park) and the perennial portions of Glorieta Creek (New Mexico Water Quality Control Commission, 1995).

Dissolved Oxygen	dissolved oxygen shall not be less than 6.0 mg/L.
pH	shall be within the range of 6.6 and 8.8.
Temperature	water temperature shall be less than 30° C (86° F).
Ammonia (total)	shall not exceed table value standard.
Fecal Coliform	the monthly geometric mean of fecal coliform bacteria shall not exceed 1000/100mL nor should any single sample exceed 2000/100mL.
Total Dissolved Solids (TDS)	TDS shall be less than 250 mg/L at flows greater than 10 cfs.
Sulfate	sulfate shall be less than 25 mg/L at flows greater than 10 cfs.
Chloride	chloride shall be less than 5 mg/L at flows greater than 10 cfs.
Arsenic	dissolved arsenic shall not exceed 0.2 mg/L.
Boron	dissolved boron shall not exceed 0.75 mg/L.
Cobalt	dissolved cobalt shall not exceed 0.05 mg/L.
Vanadium	dissolved vanadium shall not exceed 0.1 mg/L.
Radium-226 + Radium-228	Radium-226 + Radium-228 shall not exceed 30.0 pCi/l.

Table 1b. State of New Mexico chronic water quality criteria[1] and acute water quality criteria[2] for the total or dissolved (dis) fractions of heavy metals and other toxic substances (New Mexico Water Quality Control Commission, 1995).

Constituent	Chronic Criteria	Acute Criteria
Aluminum (dis)	.087 mg/L	.750 mg/L
Beryllium (dis)	.0053 mg/L	.130 mg/L
Chlorine (tot residual)	.011 mg/L	.019 mg/L
Mercury (total)	.000012 mg/L	.0024 mg/L
Selenium (total)	.002 mg/L	.020 mg/L
Cyanide (total)	.0052 mg/L	.022 mg/L
Chlordane (total)	.0000043 mg/L	.0024 mg/L
Cadmium (dis)	[3]	[3]
Chromium (dis)	[3]	[3]
Copper (dis)	[3]	[3]
Lead (dis)	[3]	[3]
Nickel (dis)	[3]	[3]
Zinc (dis)	[3]	[3]

Notes: [1] The chronic criteria shall be applied as the arithmetic mean of four samples collected on each of four consecutive days. Chronic criteria shall not be exceeded more than once every three years.

[2] The acute criteria shall be applied to any single grab sample. Acute criteria shall not be exceeded.

[3] The chronic and acute criteria of these metals are determined by an equation based upon the hardness of the water and the concentration of the constituent (Section 3101.J of the New Mexico Water Quality Standards).

radionuclides. Specific water quality criteria applicable to this river segment are provided in Tables 1a and 1b.

In addition, the New Mexico Water Quality Standards provide for an "antidegradation policy" developed to prevent degradation of high quality waters of designated national and state monuments, parks, and wildlife refuges (including waters designated by the U.S. Congress under the Wild and Scenic Rivers Act) if such degradation would impair any of the qualities which caused designation of these waters, parks, and wildlife refuges (New Mexico Water Quality Standards Section 1101.A).

In January, 1995, the New Mexico Water Quality Control Commission incorporated Glorieta Creek into stream segment 2213 of the Pecos River extending water quality standards to the entire length of Glorieta Creek (20 NMAC 6.1). This action was undertaken to protect a small, resident population of brown trout (*Salmo trutta*) as well as a substantial population of Rio Grande chub (*Gila pandora*) and longnose dace (*Rhinichthys cataractae*) found within at least the portion of Glorieta Creek flowing through Pecos National Historical Park (John Pittenger, New Mexico Department of Game and Fish, pers. comm.).

Because of its small size and intermittent flow, no designated uses have been established for Galisteo Creek. Thus, only the State of New Mexico general water quality criteria apply to these waters.

PECOS RIVER

Watershed Land Use

Pecos National Historical Park is located within the upper Pecos River watershed approximately 30 miles below the headwaters of the Pecos River. The drainage area of the Pecos River above its confluence with Glorieta Creek is approximately 265 mi^2. Much of the upper Pecos River watershed above Tererro remains relatively unspoiled. It consists of alpine grasslands, old growth sub-alpine forests of Engelmann spruce and subalpine fir, and mixed coniferous forests of Douglas-fir, white fir, and ponderosa pine. Narrowleaf cottonwoods and willows are more prevalent at lower elevations adjacent to the river. In 1990, the upper 20.5 miles of the Pecos River (from its headwaters to Tererro) was designated as a component of the National Wild and Scenic River System.

Below Tererro, however, the influence of man upon the water and riparian resources is long-standing. These influences include the impacts of agricultural, grazing, and development activities upon riparian systems; water quality degradation from abandoned mine and mill sites; water diversions; the effects of wastewater effluent discharge; and accelerated erosion patterns. Man-related influences include impacts of recreational campsite and seasonal camp development, and residential/commercial activity centered around the small communities of Cowles, Tererro, El Macho, Pecos, and East Pecos.

Water Quantity

The U.S. Geological Survey maintains two discharge (flow) gaging stations in the upper Pecos River watershed above Pecos National Historical Park. The "Pecos River near Pecos, NM" gaging station (USGS Station 08378500) is located on the Pecos River approximately 11 miles

north of the park. The "Rio Mora near Tererro, NM" gaging station (USGS Station 08377900) is located on an important tributary to the Pecos River approximately 2.6 miles north of Tererro, New Mexico.

While both stations are important in understanding the hydrology and discharge patterns of the upper Pecos River watershed, the "Pecos River near Pecos, NM" gaging station (USGS Station 08378500) is the most important from the National Park Service (NPS) management perspective. While located significantly north of the park, this site should provide a relatively accurate long-term record of flow conditions within the park.

The average flow over a 72-year period of record (1919-1991) at the "Pecos River near Pecos, NM" site was 100 cubic feet per second (cfs), which is equivalent to 72,030 acre feet per year (US Geological Survey, 1992). The maximum discharge recorded at this site was approximately 4,500 cfs which occurred during a flood event in September, 1929. However, local residents reported that greater floods had occurred on September 29, 1904 and in 1886 (U.S. Geological Survey, 1992). The minimum discharge measured at this site was approximately 2 cfs which occurred during a river freeze-up in March, 1971. River flow varies considerably during the year, with highest flows typically occurring in May and June and the lowest flows occurring from December through February.

In 1993, the USDA-Forest Service completed an instream flow study for the upper 20.5 miles of the Pecos River (Muldavin et al., 1993). This study provided an assessment of the hydrology, stream channel morphology, riparian ecosystem dynamics, and fish habitat characteristics of that section of the Pecos River included within the National Wild and Scenic River System. The study further provided instream flow recommendations considered necessary to maintain natural riparian communities and the present fish fauna and productivity regimes within three sub-segments of the study area. Completion of a similar instream flow evaluation is encouraged for both Glorieta Creek and that reach of the Pecos River flowing through Pecos National Historical Park. Such a study would not only provide essential baseline inventory information but would also be useful in developing long-term management alternatives for these important resources.

Water Quality

Water quality conditions within the Pecos River and its tributaries have been moderately well documented from the headwaters to just above the village of Pecos, New Mexico. A query of the U.S. Environmental Protection Agency's STORET data base (through 1991) indicates that the New Mexico Environment Department (NMED), Santa Fe National Forest (USDA-FS), and the U.S. Geological Survey (USGS) have collected water quality samples from over 70 locations within the watershed above Pecos National Historical Park.

Monitoring sites have included the Pecos River, tributary streams, groundwater wells, and locations of permitted point source discharges. While many of these sites have been sampled just once or infrequently, a review of the available data revealed 11 sites on the Pecos River (Table 2) and 12 sites on tributary streams (Table 3) that have been sampled eight or more times each. These tables provide information on site location, constituents monitored, and numbers of samples collected at each site.

Table 2. Water quality monitoring sites on the Pecos River upstream of Pecos National Historical Park.

SITE	LATITUDE/LONGITUDE	AGENCY	CONSTITUENTS (# of Samples)
Pecos R 0.75 mi below Pecos, NM	35 33 50.0 105 40 03.0	NMED	2c 3a 4a 5c
Pecos R at bridge above Pecos, NM	35 35 14.0 105 40 26.0	NMED	2c 3a 4a 5c 6a 8a
Pecos R at National Forest boundary	35 35 33.0 105 41 00.0	USDA-FS	1b 2b 3b
Pecos R west of Monastery Lake	35 35 40.9 105 40 54.7	NMED	2b 3c 6c 8c 9a
Pecos R below Lisboa Springs Hatchery	35 36 28.0 105 40 33.0	NMED	2c 3a 4a 5c
Pecos R at Dalton Fishing Site	35 39 16.0 105 40 56.0	NMED USDA-FS	2c 3a 4a 5c 6b 7a 8b
Pecos R above Windy Bridge	35 41 46.0 105 41 17.0	NMED	2c 3a 4a 5c 6a 8a
Pecos R above Indian Creek	35 42 30.0 105 40 55.0	NMED USDA-FS	2b 3b 6b 8b
Pecos R at Tererro, NM	35 44 33.0 105 40 36.0	NMED	2c 3c 4a 5c 6b 8c
Pecos R 400m above W. Willow Creek	35 45 40.3 105 40 16.1	NMED	2c 3c 6c 8c
Pecos R above Rio Mora confluence	35 47 00.0 105 39 27.0	NMED	2b 3b 8b

Constituents:
1 Discharge
2 Physico-chemical (e.g., temp, dis oxygen, pH, conductance turbidity, alkalinity, hardness)
3 Nutrients (e.g., NH_3, NH_4, NO_3, TKN, PO_4, TP)
4 Total organic carbon
5 Bacteria (e.g., fecal coliform)
6 Cations/anions
7 Residual chlorine
8 Metals
9 Radionuclides

# of Samples:
a - Less than 5
b - 6-15
c - More than 15

Table 3. Water quality monitoring stations on tributaries to the Pecos River above Pecos National Historical Park

SITE	LATITUDE/LONGITUDE	AGENCY	CONSTITUENTS (# of Samples)
Dalton Creek 20 m west Hwy 63 Bridge	35 39 30.6 105 41 20.0	NMED	2c 3c 5c 6b 8b
Indian Creek 3 m west Hwy 63 Bridge	35 42 27.6 105 40 59.7	NMED	2b 3b 6b 8b
Holy Ghost Creek below homes	35 44 31.0 105 40 46.0	NMED USDA-FS	1b 2b 3a
Holy Ghost Creek 300 m upstream Hwy 63 Bridge	35 44 32.3 105 40 49.7	NMED	2c 6c 8c
Willow Creek above spoils	35 44 48.0 105 39 18.0	NMED	2a 3a 6a 8a
Willow Creek 70 m above Hwy 63 Bridge	35 45 34.6 105 40 06.2	NMED	2a 3c 6c 8c
Rio Mora near Tererro, NM	35 46 38.0 105 39 27.0	NMED USGS	2c 3b 5c 6c 8c 9c 10b
Winsor Creek below homes	35 48 15.0 105 39 40.0	NMED USDA-FS	1c 2c 3b 6a 8a
Winsor Creek above campground	35 48 58.0 105 41 53.0	NMED USDA-FS	1b 2b 3a 8a
Panchuela Creek below campground	35 49 25.0 105 39 40.0	USDA-FS	1b 2b
Jacks Creek at Hwy 63	35 49 30.0 105 39 15.0	USDA-FS	1b 2b 3a 5a
Panchuela Creek above campground	35 49 45.0 105 40 53.0	USDA-FS	1c 2c 3a 5b 6c 7a

Constituents:
1 Discharge
2 Physico-chemical (e.g., temp, dis oxygen, pH, conductance turbidity, alkalinity, hardness)
3 Nutrients (e.g., NH_3, NH_4, NO_3, TKN, PO_4, TP)
4 Total organic carbon
5 Bacteria (e.g., fecal coliform)
6 Cations/anions
7 Residual Chlorine
8 Metals
9 Radionuclides
10 chlorinated Hydrocarbons

# of Samples:
a - Less than 5
b - 6 to 15
c - more than 15

While the availability of historical monitoring information is relatively good above the village of Pecos, considerably less water quality information is available for the reach of the Pecos River extending from the village of Pecos through Pecos National Historical Park. However, in January, 1994, Pecos National Historical Park began a monthly water quality monitoring program at two sites in the Pecos River within the park. Constituents monitored are currently limited to discharge, water temperature, pH, specific conductance, and dissolved oxygen. This list may be expanded in the future.

Perhaps the most severe water quality impacts in the Pecos River watershed above Pecos National Historical Park are those associated with former mining and milling activities. During the past century, one major and several minor mining operations have occurred in the upper Pecos River watershed (Jacobi and Smolka, 1982). Potential water quality issues within this reach include the effects of runoff from tailings piles at the former El Molino Mill Site; and leaching septic systems, agriculture, and effluent discharge from the Village of Pecos Wastewater Treatment Facility. This facility is located on the Pecos River approximately 0.5 mile downstream from the Highway 223 bridge. While a complete assessment and interpretation of existing water quality data is beyond the scope of this report, the National Park Service's Inventory and Monitoring Program, working in conjunction with the National Park Service Water Resources Division and Horizon Systems Corporation is completing descriptive water quality summary reports for approximately 250 units of the National Park system. The water quality summary report for Pecos National Historical Park is scheduled to be completed by late 1995 (Gary Rosenlieb, NPS Water Resources Division, pers. comm.).

Tererro Mine

The most well-known of mining operations in the upper Pecos River watershed was the Tererro Mine located on a 19 acre site adjacent to the Pecos River, approximately 14 miles north of Pecos National Historical Park.

In 1881, a prospector named J.J. Case discovered an ore body containing relatively high grade copper, lead, and zinc ores near the confluence of Willow Creek with the Pecos River. Over the next two decades several shafts were dug and adits opened to explore these ore bodies, though the appropriate milling and metallurgical processes were not then available to exploit these resources economically(McDuff, 1993).

Subsequent discoveries of silver and gold ore, as well as significant advances in milling and metallurgical technologies for refining complex ores, altered the economics enough to make mining feasible by the mid-1920s. On January 1, 1927, the American Metal Company (a predecessor of Cyprus Amax Minerals Company) began mining production at the Tererro Mine, which soon supported the largest payroll in the State of New Mexico (McDuff, 1993).

From 1927 through May, 1939, approximately 2,293,000 tons of ore from the Tererro Mine were loaded on an aerial tramway and transported 12 miles to the El Molino mill located along Alamitos Creek near Pecos, New Mexico. This ore was refined to produce more than 440,000,000 pounds of zinc; 138,000,000 pounds of lead; 19,000,000 pounds of copper; 5,000,000 ounces of silver; and 178,000 ounces of gold. It was one of the better multiple ore producers operating in the United States from the late 1920s through the 1930s (McDuff, 1993).

Today, the land surface at the abandoned Tererro Mine consists of numerous unstabilized spoil and overburden piles located on a 19 acre site along Willow Creek and in the floodplain of the Pecos River. Willow Creek flows across a portion of the waste piles before emptying into the Pecos River resulting in elevated zinc, lead, copper, and cadmium concentrations in Willow Creek and in the Pecos River below (Sinclair, 1990). O'Brien (1991) found elevated copper, zinc, selenium, and lead levels in brown trout (*Salmo trutta*) downstream from this site. In addition, the Lisboa Springs State Fish Hatchery, located 11.5 miles downstream from the Tererro Mine, has experienced major fish die-offs in raceways utilizing water from the Pecos River. It is possible that one of the factors related to these die-offs may be contaminants leaching from waste tailings piles near the site of the former Tererro Mine. These tailings are believed to be a source of high concentrations of zinc and other heavy metals periodically measured in surface flows and biota in the Pecos River (U.S. Fish and Wildlife Service, 1993).

While some minor drainage diversion work has recently been completed to divert surface runoff away from the waste rock piles, alternatives for site stabilization and remediation are currently being evaluated by Cyprus Amax Minerals Company and the New Mexico Environment Department (Johnnie Green, Cyprus Amax Minerals Company, and Stephen Wust, New Mexico Environment Department, pers. comm.).

El Molino Mill Site

The former El Molino Mill Site, currently referred to as the El Molino Operable Unit, is located northwest of the village of Pecos, on Alamitos Creek approximately 1 mile above its confluence with the Pecos River. Built by American Metals in the late 1920s, the El Molino site once contained the El Molino Mill, two tailings ponds, the southern terminus of the aerial tramway from the Tererro Mine, a coal-fired electrical generating plant, a rail spur, and housing for mill workers and dependents.

With the closure of the Tererro Mine, the El Molino site became inoperable and subsequently fell to ruin. During its period of operation, the El Molino site contained two large tailings ponds located in Alamitas Creek. Tailings Pond #1, which was approximately 35 acres in size, is estimated to contain approximately 1,000,000 cubic yards of tailings (Woodward-Clyde, 1989), with the depth of tailings averaging from 30 to 40 feet with a maximum depth at the dam of about 65 feet. Tailings Pond #2, located downstream from Tailings Pond #1, was approximately 10 acres in size, and was estimated to contain approximately 125,000 cubic yards of tailings with a maximum tailings depth of up to 30 to 35 feet at the dam (Woodward-Clyde, 1989). Lead concentrations in these tailings ranges from 2,800 to 13,000 parts per million (ppm), zinc concentrations range from 190 to 13,000 ppm, and copper concentrations range from 150 to 5,500 ppm (New Mexico Environment Department, 1993).

Surface rights were acquired for the El Molino Site by the New Mexico Department of Game and Fish in the 1950s. Over the years, inadequate maintenance was undertaken at the site, and the tailing pond dams failed in 1973, resulting in tailings dispersal downstream in Alamitos Creek, and probably the Pecos River. It is probable that erosion of the tailings by Alamitos Creek has continuously dispersed tailings downstream over the past 20 years causing downstream contamination.

Data indicate that sulfate, manganese, and total dissolved solids (TDS) concentrations in filtered groundwater samples exceeded New Mexico Water Quality Control Commission (NMWQCC)

standards or the U.S. Environmental Protection Agency (EPA) Maximum Contaminant Levels (MCLs). Cadmium, lead, iron, and manganese in surface water samples collected from Alamitos Creek were also found to be in excess of NMWQCC standards or EPA MCLs. Sediment samples in Alamitos Creek also showed elevated levels of iron, copper, lead, and zinc when compared to upstream sites (New Mexico Environment Department, 1993).

Remedial action at the El Molino Operable Unit began in 1993 under an Administrative Order of Consent (AOC) between Amax and the New Mexico Environment Department. Major actions undertaken at the El Molino Operable Unit under this AOC will include: 1) the on-site relocation and consolidation of all actionable tailing material from Tailing Pond #1 and Tailing Pond #2; 2) reinforcement of the two tailing pond dams; 3) the re-routing of a section of Alamitos Creek through an engineered channel (to reduce contamination from future tailing dispersal); and 4) the construction of a low permeability cover over the two tailing pond areas (Johnnie Green, Cyprus Amax Minerals Company, pers. comm.).

Other Contaminated Sites

Over the years, unprocessed waste rock from the Tererro Mine site has been used to construct and/or repair portions of the roadbed for New Mexico Highway 63, several USDA-Forest Service roads, and campground pads at the Jack's Creek and Panchuela campgrounds (Bruce Simms, Santa Fe National Forest, pers. comm.).

Several Forest Service roads, as well as the Jack's Creek Campground, Panchuela Campground, and Winsor trailhead were closed in 1991 due to human health exposure concerns from the use of these materials as fill. In response, the USDA-Forest Service has approved 1.2 million dollars for remediation work involving both contaminants containment and "treatment-in-place" procedures. The focus of this work will be to cap roadways where waste materials were used to reduce heavy metal runoff and to remove other material from campground areas where it is not practical to cap it on site. Materials removed from campground areas will be taken back to the original mine site (Bruce Simms, Santa Fe National Forest, pers. comm.).

This work is in progress, and the Winsor trailhead was reopened in 1992. It is expected that the Jack's Creek Campground will reopen in 1996 and the former Panchuela Campground will reopen as a picnic area sometime later (Gretchen Barkmann, Santa Fe National Forest, pers. comm.).

Pecos Wastewater Treatment Facility

The Village of Pecos Wastewater Treatment Facility is located along the Pecos River approximately 0.5 mile below the Highway 223 bridge and less than 2 miles above the boundary of Pecos National Historical Park.

The facility consists of a bar screen/grit removal chamber, two PVC-lined primary aeration lagoons, one PVC-lined secondary aeration lagoon, and a PVC-lined chlorine contact chamber. Effluent discharges to the Pecos River. The current facility was modified in 1991 to design criteria calling for treatment to 30 mg/L biological oxygen demand (BOD_5) and 90 mg/L total suspended sediments (TSS) (Gilbert Archuleta, Village of Pecos, pers. comm.).

The facility provides secondary treatment for approximately 50,000 - 60,000 gallons per day (gpd) of domestic sewage generated by residents of the village of Pecos. A review of National Pollutant Discharge Elimination System (NPDES) monitoring reports for 1993 indicates that the facility

frequently exceeds its permit limitations for biological oxygen demand (BOD_5) and total residual chlorine, and occasionally for pH (New Mexico State University, 1994).

An operational assessment conducted by New Mexico State University in June, 1994 (Haywood Martin/Robert Gott, New Mexico State University, pers. comm.) found that while the facility is well operated, it appears to be experiencing design-dependent compliance problems. These problems may have led to incidents such as the discharge from the Village of Pecos Wastewater Treatment Facility that appears to have caused a downstream fish kill in July, 1993 (Easthouse, 1993). The problems observed in the assessment are three-fold:

- First, the design for the sewage lagoon modifications in 1991 did not provide for any sludge reduction (e.g., clarifiers/digesters) or sludge removal capabilities. Thus, sludge has been accumulating in the lagoons since their first day of operation, continually affecting operational efficiencies. Sludge accumulation in the fall of 1993 was estimated to be 18 inches in Lagoon 1 (primary aeration lagoon); 11 inches in Lagoon 2 (primary aeration lagoon); 7 inches in Lagoon 3 (secondary "polishing" lagoon); and 5 inches in Lagoon 4 (chlorine contact chamber). The inability to periodically remove sludge reduces the operational efficiency of the lagoon and reduces its effective life span.

- The second problem appears to be related to a significant increase in algal production, increasing TSS and probably BOD_5 as wastewater flows through the treatment facility. The causes and possible alternatives for addressing this issue are currently being evaluated by a technical support team from New Mexico State University.

- Thirdly, with the increase in algae more chlorine is required for disinfection. The facility lacks the equipment needed to remove residual chlorine so effluent released to the river almost always contain relatively high levels of total suspended solids, frequent high BOD_5 concentrations, and chronic residual chlorine permit violations (Haywood Martin/Robert Gott, New Mexico State University, pers. comm.).

The existing water quality inventory and monitoring information downstream from the Village of Pecos Wastewater Treatment Facility is extremely limited and inadequate to assess the impacts of the effluent on water quality and the aquatic environment.

Village of Pecos Landfill

The Village of Pecos Landfill is located adjacent to Alamitos Creek downstream from the former El Molino Mill Site. No information is currently available concerning potential impacts of runoff and/or leachate from the landfill on water quality of either Alamitos Creek or the Pecos River.

Other Non-Point Source Pollution

While acknowledging that the water quality of the Pecos River above Pecos National Historical Park is generally very good (especially under normal and base flow conditions), the State of New Mexico has identified a number of non-point source pollutant concerns which could potentially affect the ability of the river to support designated uses, particularly during pulsed, high flow runoff events (New Mexico Environment Department, in preparation). In addition to impacts from sources described above, the State of New Mexico identifies potential non-point sources that include impacts from highway/road/bridge construction and maintenance, road and parking lot runoff, and improper refuse disposal and litter along the Pecos River. In addition, the Rio Mora,

Willow Creek, and Holy Ghost Creek tributaries to the Pecos River may also be susceptible to water quality degradation from logging, rangeland, and recreational development land-uses (New Mexico Environment Department, in preparation).

Fisheries Resources

The portion of the Pecos River which flows through the Santa Fe National Forest upstream of the park supports several important fisheries. The small uppermost reach of the river above Pecos Falls supports a population of Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*). From below Pecos Falls to approximately the Lisboa Springs fish hatchery, the river is primarily a non-native wild brown trout (*Salmo trutta*) fishery. The Lisboa Spring Fish Hatchery is located 3.8 miles above the north boundary of the park and is part of a "put and take" fishery program. Rainbow trout (*Oncorhynchus mykiss*) account for 95% of the hatchery's stock, with brown trout (*Salmo trutta*) making up the remaining 5% (Roddy Gallegos, NMDG&F, pers. comm.). No threatened or endangered fish species occur in this section of the river (Muldavin, 1991).

Waters within Pecos National Historical Park support populations of non-native brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*), as well as a number of native fish species including the Rio Grande chub (*Gila pandora*), longnose dace (*Rhinichthys cataractae*), white sucker (*Catostomus commersoni*), and fathead minnow (*Pimephales promelas*). There is a possibility that an additional species, the flathead chub (*Platygobio gracilis*) may be present in the Pecos River within the park, though their existence was not recorded during a 1992 fish population survey conducted by the New Mexico Department of Game and Fish surveys (Bill Stumpff, NMDG&F, pers. comm.).

No threatened or endangered fish species are known to occur within Pecos National Historical Park. It is possible, however that the Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) may have once occurred within the park (Michael Hatch, NMDG&F, pers. comm.).

The 1992 New Mexico Department of Game and Fish (NMDG&F) survey of two sites in the Pecos River within Pecos National Historical Park found good populations of non-native brown trout (*Salmo trutta)* which are rated as "comparable" when compared to other sites within the Pecos River, and as "above average" when compared with other sites statewide (Bill Stumpff, NMDG&F, pers. comm.).

Habitat Characteristics/Erosion

While information pertaining to the aquatic habitat characteristics of the Pecos River have been relatively well documented for the designated "Wild and Scenic River" segments (Muldavin et al., 1993), aquatic habitat characteristics for the reach of Pecos River within the park are not well studied. However, some insight may be gained by a limited comparative effort with similar habitat types found further upstream.

The Pecos River within Pecos National Historical Park most closely resembles the lowest reaches of the "scenic river" segment from the Muldavin et al. (1993) study. The reach of the Pecos River within the park appears to be similar to a "Type C2" reach as classified using the Rosgen classification system (Rosgen, 1985). This stream type is characterized by a channel deeply incised in coarse alluvial material. A cursory examination of the Pecos River indicates that river sinuosity is approximately 1.7 (1.7 river miles : 1.0 topographic mile). The river drops about 120 feet in

2.9 miles. The river has a clear cobble bottom substrate which appears to be favorable for aquatic invertebrates. Woody debris is generally lacking in and alongside the river in the areas observed.

Sediment starvation in the reaches of the Pecos River above the park has resulted in some moderately entrenched segments, though without the extensive gully systems noted within the Glorieta Creek system. It is possible that a large portion of the bed of the Pecos River is bedrock controlled so the potential for down-cutting is limited. This inherent stability of the main channel would prevent watershed-wide gully systems which have occurred on Glorieta Creek. The watershed is also much larger, so any impacts on a given area would affect a much smaller percentage of the watershed.

Within the park, the Pecos River is moderately confined so there is little meandering and little opportunity for the meander pattern to be interrupted.

GLORIETA CREEK

Watershed Land Use

Glorieta Creek arises on Glorieta Baldy and flows in a south/southeasterly direction for approximately 10 miles before emptying into the Pecos River. The Glorieta Creek drainage area covers approximately 35 mi^2. The uppermost portion of the watershed, above the Glorieta Conference Center (near Glorieta, New Mexico) is relatively undisturbed and contained largely within Santa Fe National Forest. Below Glorieta, Glorieta Creek roughly parallels Highway 50 and appears to be influenced by adjacent residential, agricultural, and commercial development. Glorieta Creek crosses Pecos National Historical Park in two locations. An approximate 1 mile section of Glorieta Creek is contained within the Glorieta Unit (Pigeon Ranch) and the lower 3.2 mile reach of Glorieta Creek is located within the Pecos Unit.

Water Quantity

There is no long-term discharge record available for Glorieta Creek. Flow within upper Glorieta Creek and its tributaries is intermittent, with very low flows common during the summer season. Lower Glorieta Creek generally appears to have flow, though flow may be seasonally minimal (less than 0.1 cfs). However, Glorieta Creek can rise rapidly after intense thunderstorms. In August, 1993, the park received 2.22 inches of precipitation (rain and hail) within a 3.5 hour period producing flash flood conditions in the Glorieta Creek and the flood plains associated with the Pecos River. No physical measurements were taken at the flood stage; however, empirical observations (documented by photography) indicate the creek rose at least 12 feet above normal at the Trading Post bridge.

Water Quality

Water quality information pertaining to Glorieta Creek is extremely limited. The Glorieta Conference Center operates a National Pollutant Discharge Elimination System-permitted wastewater treatment facility and conducts twice monthly effluent monitoring (NPDES Permit Number NM0028088). In addition, the New Mexico Department of Game and Fish collected periodic discharge, water temperature, dissolved oxygen, specific conductance, and turbidity data at two sites in lower Glorieta Creek in 1993 and at one site since 1994 in support of a multi-year study on the life history of the Rio Grande chub (*Gila pandora*) (Pittenger, 1993). In January, 1994, the National Park Service also began a limited water quality monitoring program at one site

in Glorieta Creek above the confluence with the Pecos River. Instantaneous discharge, water temperature, dissolved oxygen, pH, and specific conductance will be measured monthly as part of this initial monitoring effort (Bobbi Simpson, Pecos National Historical Park, pers. comm.). Overall, however, existing water quality information for Glorieta Creek appears to be extremely limited.

Glorieta Conference Center Wastewater Facility

The Glorieta Conference Center is located on Glorieta Creek approximately 3 miles upstream of Pigeon Ranch (Glorieta Unit) and 8 miles upstream of the Pecos Unit. The Conference Center is a relatively large facility, and is capable of housing 2,500 conference participants. Facility use is largely seasonal, with peak capacities reached from May through September.

The Conference Center is serviced by an activated sludge wastewater treatment facility which provides secondary treatment. The current facility appears to be at least a "third generation" retro-fit which is built upon earlier wastewater treatment facilities at the site. Wastewater first enters the "old" sewage treatment plant which serves as a primary settling basin for the wastes. From here, the waste flow enters a newer circular aeration basin where secondary treatment is undertaken. Liquids from the aeration basin then enter several large "polishing" lagoons before flowing through a chlorine disinfection basin and being discharged into Glorieta Creek (Haywood Martin, New Mexico State University, pers. comm.).

According to this process design, sludge generated in the circular aeration basin is returned to the primary settling basin where it mixes with solids generated in the primary settling basin. These solids are periodically cleaned and deposited in sludge drying beds retro-fitted from facilities at the "old" sewage treatment plant. These sludge drying beds are periodically scraped and composted with landscaping trimmings and the compost is eventually used for landscaping purposes upon the Conference Center grounds (Haywood Martin, New Mexico State University, pers. comm.).

During peak season (May - September), the facility provides secondary treatment for approximately 170,000 - 200,000 gallons per day (gpd) of domestic sewage and ground-up food wastes produced by the Conference Center's dining facilities. Effluent is discharged to Glorieta Creek, where the effluent may constitute the majority of flow during the driest months of late summer.

Prior to discharge, the effluent is monitored approximately twice per month for biological oxygen demand (BOD_5), total suspended solids (TSS), pH, fecal coliform bacteria, and oil and grease. While a review of NPDES monitoring reports from 1991 to 1993 indicated that the facility is well run and generally operates in compliance with its NPDES permit requirements, there is a possibility that the twice per month monitoring may be inadequate to provide an accurate assessment of effluent quality.

In addition, the review of the effluent monitoring data indicates that the facility frequently reports what appear to be abnormally low BOD_5 concentrations which may be indicative of problems with the analytical techniques employed. There also appears to be recurring, periodic excedances of permit requirements for oil and grease which can probably be attributed to operational problems resulting from the heavy loading of ground-up food wastes into the waste streams.

Non-point source pollution

While existing information is limited, possible water quality degradation within Glorieta Creek is a management concern at Pecos National Historical Park. The condition of residential and commercial septic systems adjacent to Glorieta Creek, streambank erosion, and possible illegal dumping remain concerns.

During site visits to Pecos National Historical Park in 1991 and 1992, staff of the NPS Water Resources Division (Long, 1991; 1992) noted that Glorieta Creek was turbid and barely flowing (approximately 0.1 feet per second). Considerable algal growth was observed on fine sand, silt and clay substrates (Long, 1992). Similarly, during a visit to Pecos National Historical Park in March, 1994, Water Resources Division staff noted the frequent occurrence of noticeable amounts of green filamentous algae throughout the lower reach of Glorieta Creek, a situation often indicative of high nutrient loading (Mark Flora, NPS Water Resources Division, pers. comm.).

Fisheries Resources

Early Spanish records indicate that Glorieta Creek supported trout (Winship, 1896). In all probability, this was native cutthroat trout (*Oncorhynchus clarki virginalis*) (Frank Panek, NPS Wildlife and Vegetation Division, pers. comm.). While a comprehensive fisheries survey has not been conducted in Glorieta Creek, the New Mexico Department of Game and Fish has found reproducing brown trout (*Salmo trutta*) in lower Glorieta Creek approximately 2.5 miles above its confluence with the Pecos River (John Pittenger, New Mexico Department of Game and Fish, pers. comm.). This section also contains significant numbers of the Rio Grande chub (*Gila pandora*), white sucker (*Catostomus commersoni*), fathead minnow (*Pimephales promelas*), and longnose dace (*Rhinichtys cataractae*).

The New Mexico Department of Game and Fish has recently begun a multi-year study in Glorieta Creek to assess the importance and relative roles of stream flow, water temperature, day length and other physical factors on the spawning of the Rio Grande chub (*Gila pandora)*(Pittenger, 1993).

Habitat Characteristics and Erosion

A cursory overview of Glorieta Creek at the Trading Post and the Forked Lightning Ranch House found a cobble substrate embedded with sediments. Few benthic macroinvertebrates were present. Additional observations and analysis of aerial photography indicated that lower Glorieta Creek is entrenched over much of its length. The lower reaches are cut to bedrock in many places. Sinuosity is approximately 1.3 (1.3 river miles : 1.0 topographic mile). The Pecos Unit portion of the creek drops approximately 160 feet in 3.25 miles. Field observations revealed little woody debris within the streambed.

Similar to many western lands, the current condition of the Glorieta Creek watershed is a result of many years of human activity that have affected natural soil stability and sediment transport processes. A survey of aerial photographs shows that nearly all of the perennial and ephemeral channels in the lower one third of the watershed are entrenched, including those in the park. Field observations show that the main channel of Glorieta Creek is entrenched 10 to 20 feet over much of its length. In its lower reaches in the park the creek has cut to bedrock in many places. Because of this incision, water levels do not often reach the floodplain during storm events (Bruce Simms, Santa Fe National Forest, pers. comm.).

Current erosional trends along Glorieta Creek itself, however, appear to be toward greater stability. Trees along the channel indicate several years have passed since there has been appreciable raising or lowering of the bed. A 1920s aerial photograph (Lindberg, 1929) shows Glorieta Creek as a wide, entrenched, braided channel with no riparian vegetation. Today that same reach remains entrenched, but has developed a single channel with some meanders, a functioning floodplain, and a mixture of grasses, willows and cottonwoods. The fact that the channel by the ruin and downstream of the Trading Post was able to tolerate the large flood of August, 1993, without loss of stability is very encouraging. Flooding might help to stimulate reproduction of woody riparian species.

Sheet and rill erosion are also apparent in some areas of the park on the former Forked Lightning Ranch. Shallow soils on 20% to 50% slopes appear prone to this type of erosion. The likely cause is reduced litter and grass cover due to grazing.

Tributary channels to Glorieta Creek are also gullied though usually not as deep. However, active headcuts along the tributary streams indicate that gully systems are continuing to expand in some areas. Active erosion could undercut structures and artifacts, damaging facilities and destroying the context of dispersed sites. Natural resources including areas of relatively productive deep soils and wetlands may also be threatened. Current status of knowledge is sufficient to know that there are extensive areas of gully erosion in the park, but specific problem areas and the location of threatened resources have not been identified.

GALISTEO CREEK

Watershed Land Use

Galisteo Creek is an ephemeral stream drainage that begins west of Glorieta Baldy and courses in a southwestwardly direction through Apache Canyon before passing through the Cañoncito sub-unit of the park. Galisteo Creek then continues its southwestwardly flow through the village of Lamy, eventually joining the Rio Grande near the Santo Domingo Pueblo.

The drainage area of Galisteo Creek above the Cañoncito sub-unit consists of approximately 26 mi^2 of relatively undeveloped land within Santa Fe National Forest, though some grazing use occurs in the immediate vicinity of Cañoncito. The Santa Fe Railroad and Interstate 25 traverse the sub-unit and four private residences are located in the drainage in the Cañoncito area.

Water Quantity and Water Quality

Galisteo Creek is usually dry in the vicinity of the Cañoncito sub-unit. It may, however, respond rapidly to local rainfall producing flash-flooding conditions. No current information is available pertaining to the water quality within Galisteo Creek in the vicinity of the park.

OTHER WATER-RELATED RESOURCES

Reservoirs

Four reservoirs are known to exist within the boundaries of Pecos National Historical Park: two along Glorieta Creek between the Trading Post and the Forked Lightning Ranch House; one extending into the park along the southern boundary of the Pecos unit; and one that captured

Trading Post Spring just northeast of the Trading Post. The first two reservoirs are of fairly recent origin, while the latter two are likely historic features.

The two reservoirs along Glorieta Creek are locally known as the upper reservoir and the lower reservoir. Both are in poor condition and will require significant maintenance or removal. They were constructed in the 1980s on a low terrace or floodplain adjacent to the creek. The surface area of the upper reservoir is estimated to be 9 acres, and the surface area of the lower is estimated to be 6 acres. Both have spillways that will allow the impoundment of water to a depth of about 6 feet, and a maximum capacity of approximately 54 acre-feet and 36 acre-feet, respectively. A cut at the top of the upper reservoir diverts a portion of high flows in the creek which, in turn, spills into the lower reservoir. Both dams are in poor condition, neither have stable spillways, and the inflow is largely uncontrolled. The lower dam was breached prior to the 1992 aerial photographs. The upper dam nearly failed during the flood of August, 1993. It would likely have failed had the flood been a few hours longer in duration.

Along the south boundary of the Pecos Unit, an old railroad grade has been maintained as a dam to capture ephemeral flows. The dam is located about 600 feet south of the boundary on private lands, and backs water approximately an additional 600 feet into the park. When full, the impoundment has a surface area of approximately 30 acres. Approximately 480 acres of land drain into this reservoir.

A small pond captures water from Trading Post Spring before it can flow into Glorieta Creek. It is less than one-eighth acre in size. The pond and spring development was apparently the historic water supply for the Trading Post. It contains a concrete spring box, a fish screen across the spillway, and two pipelines that once crossed Glorieta Creek toward the station. These may be historic resources. A portion of the flow spilling over the earthen impoundment away from the spillway does not appear to threaten the integrity of the impoundment at this time, but should be corrected to assure the future integrity of the reservoir.

Groundwater

Groundwater in the Pecos region is found in the Precambrian crystalline rocks, the Pennsylvanian Madera Formation, and in the coarse grained Quaternary sediments adjacent to the streams. It is likely that recharge to the upper member of the Madera Formation occurs primarily through outcrops of the sandy units and to some extent of limestone members.

Regional and subregional evaluations of hydrology suggest that shales overlaying the Madera Formation are confining beds of very low permeability units. Groundwater in useable quantities in the Sangre de Cristo Formation occurs in the sandstone members. Recharge to the unit occurs predominantly across sandstone outcrops. Because of the interbedded shales, vertical recharge to the Sangre de Cristo Formation (and therefore to the underlying Madera Formation) is considered to be very limited. Water level contours in the vicinity of Pecos indicate that the Pecos River receives inflow from the surrounding water table (AMAX, Inc. 1993).

Wetland and Riparian Resources

Significant riparian areas are found adjacent to perennial (and some ephemeral) surface waters in Pecos National Historical Park. An increasingly rare resource in the arid southwest, riparian and wetland habitats support a diverse community of flora and fauna. Glistening ribbons of water contribute to the integrity of a cultural landscape that once supported a diversity of peoples.

Throughout most of the park, semi-arid soils, low rainfall and general topography preclude wetlands except near streams and springs. Vegetative cover maps, based primarily on 1992 aerial photographs (with limited field checks) show approximately 180 acres (2.8 percent) of the park in floodplain meadows and 36 acres (0.6 per cent) in riparian deciduous forest (Rodriguez-Bejarano, 1992).

In the Pecos Unit, the riparian communities and other wetlands occur along the Pecos River, Glorieta Creek, and by Poison Spring. In winter and spring, the south boundary impoundment periodically backs up water onto a small flat area and is occasionally used by waterfowl. Riparian and wetland communities also occur along Glorieta Creek in the Pigeon's Ranch area and along Galisteo Creek in the Cañoncito sub-unit.

In 1974, the U.S. Fish and Wildlife Service's National Wetlands Inventory program mapped wetlands within the Santa Fe and San Miguel Counties. The 1":100,000" scale is quite broad and provides limited information. The following classifications were assigned to wetlands within the park:

Glorieta Creek
PEMIA = Palustrine/emergent/persistent/temporarily flooded
PEMIJ = Palustrine/emergent/persistent/intermittently flooded
PEMIC = Palustrine/emergent/persistent/seasonally flooded
PUSAh = Palustrine/unconsolidated shore/diked - impounded
R3USA = Riverine/upper perennial/unconsolidated shore/temporarily flooded
R30WH = Riverine/upper perennial/open water/permanently flooded
R4SBA = Riverine/intermittent/streambed/temporarily flooded

Pecos River
PFO14 = Palustrine/forested/broad-leaved deciduous/needle-leaved evergreen
R30WH = Riverine/upper perennial/intermittently flooded/permanently flooded
PSS1A = Palustrine/scrub-shrub/broad-leaved deciduous/temporarily flooded

Drainages
R4SBJ = Riverine/intermittent/streambed/intermittently flooded
R4SBA = Riverine/intermittent/streambed/temporarily flooded

South Boundary
PEM1A = Palustrine/emergent/persistent/temporarily flooded

Palustrine systems include all non-tidal wetlands with greater than 30% cover by trees, shrubs, persistent emergents, emergent mosses or lichens. Palustrine systems include marshes, bogs, fens, and prairies and may be situated shoreward of river channels or on floodplains. Riverine systems include all wetlands and deepwater habitats contained within a channel except for wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens. Water is usually, but not always, flowing in the riverine system. Springs discharging into the channels are considered part of the riverine system.

The New Mexico Natural Heritage Program surveyed and mapped approximately 2.5 miles of the riparian and wetland ecosystems along the Pecos River in the Forked Lightning Ranch (Muldavin,

1991). Four major physiognomic divisions were identified: cottonwood riparian forests, willow riparian shrublands, wetlands, and uplands. The first three divisions may be classified as wetlands under criteria established for the National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service criteria (Cowardin, et al., 1979). The Army Corps of Engineers may also classify them as jurisdictional wetlands. Both classification systems criteria are protected under Section 404 of the Clean Water Act.

Cottonwoods, boxelder and willows dominate the riparian plant community along the Pecos River and Glorieta Creek. Other plants include tamarisk, cattail, and rushes. The oldest stands of cottonwoods along the river sprouted before the turn of the century. Muldavin (1991) described the cottonwood/boxelder plant association as the climax community in areas that are subject to periodic flooding or are near the surface water table.

Muldavin (1991) also identified three small, scattered wetland communities: cattail swamp; water sedge/baltic sedge wetland; and a shrubby sandbar willow/horsetail wetland. These wetlands occur in areas where there is permanent standing water (generally spring fed) or are periodically flooded. They correspond in the NWI classification to palustrine wetlands.

The Pecos River riparian area, undoubtedly the most important feature within the park for wildlife, provides habitat for breeding, feeding, shelter, and a route for migrations. A 1993-94 survey documented the occurrence of 24 mammals, 7 reptiles, 2 amphibians, and 189 arthropods (Parmenter and Lightfoot, 1995). Other wildlife expected to frequent riparian areas include bats, raccoons, skunks, gray and red fox, mink, beaver, garter snakes and amphibians. The park also provided historic habitat for the river otter (National Park Service, 1994).

Mukai (1989) concluded that the Pecos River riparian area is the most important bird habitat at the Los Trigos and Forked Lightning Ranch. Of the 109 species she recorded, the highest number occurred most frequently in riparian areas and wetlands. Although riparian habitat comprises only four percent of the ranch, more than half of the recorded nest sites were located there. Dead or dying cottonwoods provided suitable habitat for cavity nesting species.

Floristic and wildlife surveys for the entire park have recently been completed (Sivinski, 1995; Parmenter and Lightfoot, 1995). These surveys provide additional wetlands related information. In addition, Witham (1993) and Muldavin (1991) identified unique stands of hybrid lance-leaf cottonwoods (*Populus acuminata*) (Witham, 1989) along Glorieta Creek and the Pecos River. This species is believed to be a cross between narrow-leaf cottonwood (*P. angustifolia*), found at higher elevations, and plains cottonwood (*P. deltoides*), found at lower elevations.

Several rare plant and animal species may occur in riparian areas in the park. The federally endangered bald eagle (*Haliaeetus leucocephalus*) winters in the upper and middle Pecos valley. The federally endangered American peregrine falcon (*Falco peregrinus anatum*) prefers areas with steep rocky cliffs near water. It could nest in the rugged canyons east of the Pecos River.

The Southwestern willow flycatcher (*Empidona traillii etimus*), a federally endangered species, may inhabit the park's willow-cottonwood riparian area. In 1992, a pair was identified nesting 3.3 miles upstream from the park. The gray vireo (*Vireo bellii*), a state endangered songbird, also uses the park (Parmenter and Lightfoot, 1994). It usually occurs in dense shrubs or woodlands along lowland stream courses.

The state endangered Say's pond snail (*Lumnaea caperata*) occurs in marshes, streams and ponds that are seasonally dry and has been reported at sites within 20 to 30 miles from the park. While it has not been reported within the park, suitable habitat may occur in ponds and at the base of cliffs south of the Forked Lightning Ranch House. The dense, diverse streamside vegetation, wet meadows and cattail stands at the ranch could also provide suitable habitat for the meadow jumping mouse (*Zapus hudsonius*), another state endangered species (National Park Service, 1994).

WATER RESOURCE ISSUES RELATED TO PARK DEVELOPMENT AND OPERATIONS

Floodplains

An important factor for the siting of park facilities is floodplain location. The Pecos River floodplain provided opportunity for agricultural activity and trade routes directly contributing to settlement patterns for hundreds of years.

Based on the alluvial terraces, soils, and vegetation, the drainages in the park flooded frequently in the past. Most flooding probably happens in the spring when snowmelt runoff is carried down from the mountains, and in the summer when intense thunderstorms occur. Although precipitation in most places is almost immediately absorbed by the park's soils, Glorieta Creek and the arroyos can flash flood during thunderstorms. In August, 1993, the stretch of Glorieta Creek below Pigeon Ranch flash flooded. Trees and other debris were strewn about near the confluence with the Pecos River.

The Federal Emergency Management Agency (FEMA) has mapped the major drainages within the park boundaries for flood insurance rates. Community panels 350132-0019A and 350069-0275B show the 100-year flood boundaries for the park; 500-year flood boundaries have not been mapped. The 100-year flood boundaries for the Pecos River, Glorieta Creek, and Galisteo Creek within the park are narrow, generally averaging about 500 feet or less in width. No base flood elevations were determined by FEMA. However, all of the proposed and existing park facilities are on terraces well above these floodplains (National Park Service, 1994).

Water Rights

None of the lands within the park's authorized boundaries were reserved from the public domain. Therefore, in accordance with current NPS policy, federal reserved water rights will not be asserted. Some park water sources may be protected by state appropriative water rights. Information on the current status of water rights is available from park maintenance files, State Engineer's Office files, and a water rights assessment completed by the NPS Water Resources Division.

New Mexico water law establishes the right to use water based on appropriation for beneficial use. These rights are considered real property with beneficial use defining the basis, the measure, and the limit and priority in time giving the better right. Beneficial use is broadly interpreted to include any purpose as long as it does not waste water. However, appropriation of water is interpreted to require diversion. The state currently has no statute to allow a water right to maintain un-diverted water in-stream.

Since March 19, 1907, any right to use surface water must originate by application to the State Engineer. An exception to this application requirement is made for stock water impoundments less than 10 acre-feet in capacity. State of New Mexico regulations also allow that groundwater be appropriated for beneficial uses without application unless the withdrawal occurs within the boundaries of a declared underground water basin. The entire area within the park boundary is currently within one of two declared underground water basins. The upper Pecos Basin, declared February 24, 1972, includes park lands on the east side of the drainage divide between Glorieta Creek and Galisteo Creek. The Rio Grande Underground Water Basin, declared December 31, 1970, includes park lands on the west side of this drainage divide. Therefore, all rights to ground water (wells and springs on park lands) established after the declaration date must have applications filed with the State Engineer.

Adjudications are proceeding in which the right to use water is established by a State or Federal court. If an adjudication is conducted according to the requirements of the McCarran Amendment (43 USC 666) and the court so orders, all claims to water use relying on any legal doctrine must be declared or forfeited. This includes water rights established by application to the State Engineer, by appropriation prior to State regulation (vested rights), and by reservation under Federal law (reserved rights). Park lands within the Pecos River and Glorieta Creek watersheds are included in the Pecos River Basin Adjudication area. Adjudication of water rights in this area is expected to take place over the next 3 to 4 years (Max A. Chavez, State of New Mexico, pers. comm.).

Surface Water

The following is a listing of surface water sources and developments in the park:

- **Pecos River** (Pecos Unit)

  Mill Diversion Ditch. The mill was disassembled in the 1920s; however, an offsite wooden dam on the Pecos River and an accompanying diversion ditch was likely used through the 1950s for agricultural irrigation on the Forked Lightning Ranch. Pumps were probably used in later years after the wooden dam was washed out. Remnants of irrigation (black plastic pipe and diversion ditches) are evident. Documentation of the permit for this water right is on file in the State Engineer's Office.

- **Poison Spring** (Pecos Unit)
  An unimproved spring located near the historic ruins area is thought by historians and cultural resource specialists to have been an important source of water to the Pueblo and later to the Mission during their occupation periods. However, there is no documentation of recent use of this water on file in the State Engineer's Office.

- **Glorieta Creek** (Pecos Unit and Glorieta Unit)

  Reservoirs. Four reservoirs can be found in the park. Two are located along Glorieta Creek near the Trading Post (approximately 6 acres and 9 acres maximum surface area respectively), a third reservoir can be found near the park's south boundary and a fourth one is adjacent to

the spring near the Trading Post. There is no documentation of these water uses on file in the State Engineer's Office.

Cistern/Pumphouse at Forked Lightning Ranch House (Big House). Water for the Ranch House was pumped from a cistern on Glorieta Creek, probably through the 1940s, possibly until the new well above the house was drilled in the 1950s. There is no documentation of this water use on file in the State Engineer's Office.

Other Historic Diversions/Uses. For the Pecos Unit other diversions and uses are unknown and/or undocumented, but uses were likely involved during Pueblo, Spanish and Anglo occupation periods. Associated rights, if any, are unknown. Diversions and uses in the Glorieta Unit are unknown and/or undocumented, but some uses are likely with current or former landowners.

- **Trading Post Spring near Glorieta Creek.** This water source was used historically as a water supply for the Trading Post and Forked Lightning Ranch headquarters. The spring box collected water which was pumped to buildings and was active through the late 1970s. There is no documentation of this water use on file in the State Engineer's Office.

- **Middle Pasture Spring.** This unimproved spring with an intermittent flow is located 300 yards south of the middle pasture well. There is no documentation of this water use on file in the State Engineer's Office.

- **Mud Spring.** This spring, located 1/2 mile south of Forked Lightning Ranch House (Big House) has a mudflow. It is near an old collapsed well and stock pond impoundment. There is no documentation of this water use on file in the State Engineer's Office.

- **Galisteo Creek** (Cañoncito Sub-Unit). Historic diversion/uses are unknown, but some uses are possible with current landowners.

Wells

The National Park Service has water rights recorded at the State Engineer's Office for only one of the four wells (the well servicing the administrative area) used in the operation of the park. In the Glorieta Unit, existing dwellings probably have small domestic and stock wells which may or may not be recorded with the State Engineer's office. As these facilities are acquired, existing water rights associated with them would also be acquired. The following is a list of groundwater sources.

- **Well in Administration Area** (Declaration of Water Right #UP-500). (NW1/4, NW1/4, NE1/4, Section 8, T15N, R12E) This well was drilled to a depth of 100 feet below the surface sometime prior to December 7, 1941, and subsequently redrilled to a depth of approximately 300 feet in 1951. A Declaration of Water Right was filed with the State Engineer's Office on July 18, 1978, for this well which services the park's administration area.

- **Well at the Visitor Center.** A well to provide potable water to the current park Visitor Center was drilled by the NPS in the 1980s. However, no documentation of this water use

was found on file in the State Engineer's Office. It is recommended that the park apply with the State Engineer's Office for the permit required to use this water.

- **Two Wells by Ruins/Poison Spring.** Applications were approved by the State Engineer's Office on August 1, 1978, to drill two exploratory wells (UP-x1 (location NE1/4, NE1/4, SE1/4, Section 5, T15N, R12E) and UP-x2 location SW1/4, SE1/4, SE1/4, Section 5, T15N, R12E)) near the Ruins/Poison Spring to support the planned site for the park's proposed Visitor Center. While both wells were successfully drilled (to 300 feet and 500 feet), and capped for future use, the presence of cultural resources near the proposed site of the Visitor Center caused its location to be moved.

  Should the park decide that it is unlikely these wells will be used to supply water needs in the future, State of New Mexico regulations require that the wells not to be used for park purposes (as defined by their permits) be properly plugged and abandoned. The Water Rights Branch of the Water Resources Division could assist the park in determining either the appropriate approach for deciding if these wells will be used for park purposes, or determining requirements for abandoning the wells according to state regulations. In either case, further permit needs and requirements defined by the State Engineer's Office will need to be met.

- **Well at the Trading Post** (Kozlowski's Stage Stop). This well was drilled by the Forked Lightning Ranch to a depth of 350 feet around 1978. While this well is currently used to supply potable water to administrative offices and a residence, there is no documentation of this water use on file in the State Engineer's Office. It is recommended that the park apply with the State Engineer's Office for the permit required to use this water.

- **Well at Forked Lightning Ranch House.** This well was probably drilled by the Forked Lightning Ranch in the 1950s to a depth of approximately 800 feet to supply potable water to the Ranch House and Casita. While this water is still being used as a potable water supply by the park, there is no documentation of this water use on file in the State Engineer's Office. It is recommended that the park apply with the State Engineer's Office for the permit required to use this water.

- **Stock Well in Middle Pasture** (Forked Lightning Ranch). This well was possibly drilled by the Forked Lightning Ranch in the early 1980s to a depth of 325 feet. There is no documentation of this water use on file in the State Engineer's Office.

- **Well at Glorieta House** (NE1/4, NE1/4, SE1/4, S34, T16N, R11E). In the Glorieta Sub-Unit, the well was drilled in September, 1981, to a depth of 90 feet. Water is heavily contaminated and not currently being used. There is no documentation of this water use on file in the State Engineer's Office.

- **Well at Alvarez House.** This Glorieta sub-unit well has no written information available. There is no documentation of this water use on file in the State Engineer's Office.

While the status of water rights of the remaining wells has not been documented by the park, a recent conversation with the New Mexico State Engineer's Office indicated that wells drilled prior to 1972 need to be registered and that the park is required to transfer the registration to denote the

change of ownership. Wells drilled after 1978 require permits which need to be registered in the name of the new owner (Ronald E. Palmer, NM State Engineer's Office, pers. comm.). It will be necessary for the park to update these well permits to indicate the recent change in ownership with the acquisition of the Forked Lightning Ranch.

Potable Water Supply

Potable water systems at the Pecos National Historical Park Headquarters, Visitor Center, Ranch House and Casita, and the Trading Post have all been tested and managed for compliance with National Primary Drinking Water Regulations, the State of New Mexico Drinking Water Regulations, and the NPS Public Health Management Guidelines (National Park Service, 1993).

Several surveys of these systems have been conducted and provide the following overview of potable water quality in the park water supply systems (Sacoman, 1993; New Mexico Environment Department, 1994; National Testing Laboratories, 1994):

- **Park Headquarters:** Water for the Headquarters site is obtained from a drilled well on the west side of the picnic area. The system is classified as a public non-community system and is chlorinated. The water generally meets the requirements of the national and state regulations as well as NPS guidelines with the exceptions of sodium (221 mg/L; NPS action level = <200 mg/L), and total dissolved solids (TDS) (605 mg/L; Maximum Contaminant Level (MCL) = 500 mg/L. A reverse osmosis system is due to be installed on the primary drinking water fountain at the site (John Gibson, Pecos National Historical Park, pers. comm.).

- **Visitor Center:** Potable water for the Visitor Center is supplied from a 300-foot well drilled approximately 50 feet east of the building. The system is classified as a public non-community system and is chlorinated. The system meets the requirements of the national and state regulations as well at the NPS guidelines with the exception of iron (1.6 mg/L; MCL = .3 mg/L) and manganese (.056 mg/L; MCL = .05 mg/L). Sodium has also been observed to be at elevated levels, but meets compliance. A reverse osmosis unit will be installed on the primary drinking water fountain at the Visitor Center (John Gibson, Pecos National Historical Park, pers. comm.).

- **Ranch House and Casita:** Water for the Ranch House and Casita is obtained from a drilled well located approximately 1/4 mile from the Ranch House. Water is stored in a galvanized steel water storage tank. From there, water is chlorinated and stored in four pressure tanks before being used to supply four residential apartments. The water meets the requirements of the national and state regulations as well as NPS guidelines. TDS has been reported at elevated levels, but still is in compliance. A reverse osmosis system may be added later to this system (John Gibson, Pecos National Historical Park, pers. comm.).

- **Trading Post:** Water is supplied to the administrative offices and one apartment located at the Trading Post from a well located approximately 300 feet from the building. The system has not been classified. A chlorinator has been installed on the system. Water has been out of compliance for TDS (592 mg/L; MCL 500 mg/L) and pH (9.6; standard is between 6.6 and 8.8). A reverse osmosis system is being planned for installation in the apartment (John Gibson, Pecos National Historical Park, pers. comm.).

Wastewater Management

Pecos National Historical Park has wastewater facilities at Headquarters/Comfort Station, the Visitor Center, the Ranch House and Casita, and the Trading Post.

- **Headquarters/Comfort Station:** Wastewater from the headquarters building is discharged to a 1,000-gallon concrete septic tank and drainfield located on the east side of the building. No problems were reported for this system (John Gibson, Pecos National Historical Park, pers. comm.).

  Wastewater from the comfort station is discharged into a 1,000-gallon concrete septic tank located behind the comfort station. Effluent from this septic tank runs to a splitter box located just north of the evapotranspiration beds. The two evapotranspiration beds receive effluent from the comfort station and the visitor center septic tanks. Effluent from the two septic tanks can be put in either bed by using the splitter box. There is a recurring problem with these evapotranspiration beds. When visitation is high the effluent rises to the ground surface, creating a health hazard and an artificial habitat for mosquito production.

- **Visitor Center:** Wastewater from the visitor center is discharged to a 1,000 gallon septic tank located at the east end of the building. Effluent from the tank flows by gravity to a wet well pumping station located on the south side of the entrance road. It is pumped from there to the influent side of the septic tank serving the comfort station at the headquarters area.

- **Ranch House and Casita:** The existing facilities at the Ranch House and Casita include a septic tank and drainfield system for each building. The systems for the Ranch House and Casita were replaced in 1994. It is expected these improvements will provide adequate sewage management at the Forked Lightning Ranch House and Casita for the foreseeable future.

- **Trading Post:** The Trading Post has a septic tank and drainfield system that was checked and pumped in the spring of 1992. The system is in good condition and can continue to be used for this site as long as the use does not change significantly.

WATER RESOURCE PLANNING ISSUES AND RECOMMENDATIONS

WATER QUALITY

Water Quality Standards Revision

The New Mexico Water Quality Control Commission has designated the main stem of the Pecos River from Anton Chico upstream to the mouth of Alamitos Canyon, perennial portions of Glorieta Creek, and perennial reaches of the Gallinas River from its mouth upstream to the diversion for the Las Vegas Municipal Reservoir and Glorieta Creek for use as irrigation water, livestock watering, wildlife habitat, marginal coldwater fishery, and secondary contact recreation (New Mexico Water Quality Standards Section 2213). These include the waters of the Pecos River and Glorieta Creek within the expanded boundary of Pecos National Historical Park. To protect these beneficial uses, the New Mexico Water Quality Control Commission has developed numeric water quality criteria for a number of water quality constituents including water temperature, dissolved oxygen, pH, fecal coliform bacteria, total dissolved solids, ammonia, chloride, sulfate, chlorine, metals, and radionuclides.

In light of the 1990 park expansion, which resulted in the inclusion of a significant reach of the Pecos River and Glorieta Creek within a unit of the National Park System, the adequacy of the current designated use classifications, and the protection of waters within the park under New Mexico's antidegradation policy should be more clearly assessed. Currently, the designated uses and applicable water quality criteria for the Pecos River (and tributaries) north of the confluence of Alamitos Creek to its headwaters are much more resource protective than the water quality standards within the park.

In addition, the New Mexico Water Quality Standards provide for an "antidegradation policy" developed to prevent degradation of high quality waters of designated national and state monuments, parks, and wildlife refuges if such degradation would impair any of the qualities which caused designation of these waters, parks, and wildlife refuges (New Mexico Water Quality Standards Section 1101.A). The applicability and meaning of this "antidegradation policy" to waters included within the expanded boundaries of Pecos National Historical Park are unclear.

Recommendations:

Expansion of the current boundaries of Segment 2214 southward by approximately an additional 7 river miles, to include the Pecos River to the confluence of Glorieta Creek is recommended. This change in designated uses to protect high quality coldwater fishery, domestic water supply, fish culture, irrigation, livestock watering and wildlife habitat, and secondary contact recreation would provide more adequate water quality protection consistent with the status accorded Pecos National Historical Park as a unit of the National Park system. Implementation of this recommendation would occur through action of New Mexico Water Quality Control Commission. The NPS should pursue this issue with the Commission in conjunction with the New Mexico Department of Game and Fish and the Village of Pecos.

In addition, it is recommended that Pecos National Historical Park communicate with the New Mexico Environment Department and the New Mexico Water Quality Control Commission to

define the applicability and implication of the State of New Mexico's water quality "anti-degradation policy" upon the waters flowing through Pecos National Historical Park. These issues are further addressed in Project Statement PECO-N-005.006 (Appendix A).

Improved Water Quality Inventory and Monitoring Implementation

Surface Water Quality Monitoring

Water quality concerns on the Pecos River include both potential point source and non-point pollutant sources including the Tererro Mine and El Molino Mill sites; the Village of Pecos Wastewater Treatment Plant; the Lisboa Fish Hatchery; gravel mining on Alamitos Creek; Village of Pecos Landfill; and other sources such as septic system leachate and highway runoff throughout the watershed. Of most pressing concern is the extent of contamination of the Pecos River due to non-point sources, primarily waste from the inactive Tererro Mine and El Molino mill site and potential impacts from NPDES compliance problems at the Village of Pecos Wastewater Treatment Facility.

Glorieta Creek appears to be undergoing nutrient loading (nitrates and phosphates) from unknown sources that are causing eutrophication and filamentous algal growth along the watercourse (National Park Service, 1994). The discharge from the Glorieta Conference Center wastewater lagoons, condition of residential septic systems along Glorieta Creek, impacts associated with road construction along Highway 50, irrigated agriculture, and livestock grazing may all contribute to nutrient and sediment loading and algal growth. No data presently exist to support these possibilities, but visual evidence lends weight to these suspicions.

Water quality monitoring information, especially in the Pecos River below the village of Pecos and Glorieta Creek is currently limited and inadequate to characterize or assess potential water quality problems. A two year study being conducted by the New Mexico Highlands University and the New Mexico Environment Department is being initiated to identify and assess potential water quality problem areas. Study objectives include determining existing conditions and pollution sources for the Pecos River and Glorieta Creek, establishing baseline conditions for potential development of anti-degradation criteria, and if necessary, establishing a cost-effective protocol for future water quality monitoring (Jacobi, 1995).

Recommendations:

The park should take a more active role in the interagency task force responsible for improving Pecos River water quality. Although the agency has no direct responsibility for cleanup of the Tererro Mine and mill sites, its involvement in such a group would provide the park with an ability to influence the location, frequency, and extent of follow-up monitoring, especially for areas within the park.

The park is also encouraged to work closely with the State of New Mexico and the Village of Pecos to develop an adequate sampling routine to monitor potential impacts to the park from the Village of Pecos Wastewater Treatment Facility. The park should also work through the State of New Mexico water quality standards triennial review process to assure adequate protection of park water quality and aquatic biological resources.

Fecal coliform, nutrients (nitrate and phosphate), chloride, and turbidity analyses coupled with biomonitoring data would be useful on Glorieta Creek. Based upon the results of the Jacobi (1995)

study, the park may consider requesting NMED to increase the number of parameters included for monitoring wastewater at the treatment plants in Pecos and the Glorieta Conference Center.

Similar analyses along with heavy metal scans would be useful in the Pecos River. Recommendations relating to water quality-related management actions are further addressed in Project Statements PECO-N-005.006 and PECO-N-005.009 (Appendix A).

Water Quality in Wells

There are four wells being used for drinking water in the park including the Visitor Center, administration building, Trading Post, and the Ranch House/Casita. Data from NPS-initiated water supply monitoring efforts indicate that some wells, while meeting contaminant criteria required in the State of New Mexico Drinking Water Rules (New Mexico Drinking Water Rules Section 202), may sometimes fail to meet criteria recommended in NPS public health guidelines (National Park Service, 1993b).

While meeting State of New Mexico Drinking Water Rules, the well at the Visitor Center has failed to meet NPS guidelines (National Park Service, 1993b) for methylene chloride (1.6 mg/L; MCL = 0.2 mg/L), iron (1.6 mg/L; NPS MCL = 0.3 mg/L), and manganese (0.056 mg/L; NPS MCL = 0.05 mg/L) at least one time over the last three years for each element.

The well at the administration building also met State of New Mexico Drinking Water Rules but has failed to meet NPS guidelines for pH (9.0; guideline = 6.6 to 8.8) and TDS (521 mg/L; MCL = 500 mg/L) at least one time over the last 3 years.

The Trading Post potable water system likewise met state criteria but has failed to meet NPS guidelines for two constituents: TDS (592 mg/L; MCL = 500 mg/L) and pH (9.6; guideline = 6.6 to 8.8).

The well at the Ranch House and Casita were shown to meet both state criteria and NPS guidelines for drinking water, though TDS levels were somewhat high and should be monitored.

Well water test results at the Donald House on Glorieta Unit failed to meet all NPS guidelines for parameters tested and should be considered unsafe to drink.

Recommendations:

A comprehensive potable water quality testing program was undertaken for all potable water supplies within the park in 1993 and 1994 (John Gibson, Pecos National Historical Park, pers. comm.). Sodium and total dissolved solids were found to be high in several wells and small scale (approximately five gallons per day) reverse osmosis systems are being fitted on primary drinking water supplies. With the completion of this monitoring, the park currently meets all requirements of the State of New Mexico and as outlined in NPS-83 Public Health Guidelines (National Park Service, 1993b).

AQUATIC BIOLOGICAL RESOURCES AND FISHERIES

Status/Species Diversity and Habitat Characteristics

Pecos National Historical Park staff have a limited knowledge of fish species composition within the park's two main water features, the Pecos River and Glorieta Creek. However, there is a lack of inventory and monitoring information capable of detecting aquatic biological resource trends that may result in response to natural and man-induced changes, including recreational fishery activities.

Recommendations:
In order to address this issue, the following inventory efforts are recommended:

- compile information on past aquatic fisheries management activities conducted by the New Mexico Department of Game and Fish, National Park Service, and other agencies within the upper Pecos River and Glorieta Creek watersheds;

- produce a channel morphology map in a manner that will allow comparison of this map with a similar inventory conducted on the Pecos River upstream of the park (Muldavin, et al., 1993); and,

- develop a basic inventory of aquatic biological resources that incorporates assessments of stream habitat, biological diversity, community composition, relative species abundance, and overall productivity.

Specifics pertaining to these recommended activities are developed in Project Statement PECO-N-002.005 (Appendix A).

Biotoxicity and Contamination

Contaminant assessments have revealed elevated levels of heavy metals including zinc, copper, lead, and cadmium from the Tererro Mine wastes entering Willow Creek and the Pecos River approximately 14 miles north of Pecos National Historical Park (Sinclair, 1990). In addition, O'Brien (1991) found elevated levels of lead, zinc, and selenium in fish tissue sampled below the Tererro Mine. At the former El Molino Mill Site, high concentrations of copper, lead, and zinc have also been documented in mine tailings located along Alamitos Creek, a tributary which enters the Pecos River approximately 4 miles above the park. However, results of any existing samples for contamination of aquatic biological resources immediately downstream from this potential source by other entities were not available to the National Park Service at the time of this report.

Because of these potential contaminant sources, the National Park Service conducted a reconnaissance-level assessment of fish tissue contamination during the summer of 1992 in the Pecos River flowing through the park (Irwin, 1993). While this initial assessment monitored contaminants in only six fish tissue samples (two brown trout, two longnose dace and two white suckers), the results provided a fairly strong indication of potential contamination for several trace contaminants. Levels of arsenic, chromium, and lead were found to be high enough in fish samples to cause possible concern for fish and wildlife predators and potentially, for humans who consumed large amounts of fish from the river. Other contaminants (cadmium, mercury, selenium and PCB (arochlor 1262)) were also found to be somewhat elevated in some of the specimens, and at levels that would warrant further study (Irwin, 1993).

Because of these results, a more thorough follow-up assessment was conducted by the National Park Service in 1993 which assessed contaminant levels in 32 fish specimens, including 16 brown trout (fillet and whole body samples), and 16 white suckers (whole body only), and contaminant levels in two water samples and four sediment samples (Irwin, 1994). While the results of this assessment are still not sufficient to draw definitive conclusions, whole body concentrations of chromium, lead, and mercury were found to be high in most of the fish specimens, and exceeded levels considered to be safe for predator consumption. In addition, some of the fillet samples were found to be above national mean values for chromium (2), lead (2), mercury (1), and cadmium (1) and two of the fillets had lead concentrations approaching the recommended limit for human consumption (Irwin, 1994).

Recommendations:
Based upon these results and the results of earlier sampling in the vicinity of the Tererro Mine, the Water Resources Division recommended continued monitoring of whole body and fillet samples of fish from the Pecos River within the park for contaminants including arsenic, cadmium, chromium, copper, lead, mercury, selenium, silver, mercury, and zinc (Irwin, 1994). In addition, further consultation with the National Park Service public health and contaminants specialists as well as State of New Mexico public health officials is encouraged to guide the park concerning any necessary warnings pertaining to fish consumption. These activities are recommended as a component of Project Statement PECO-N-002.005.

WETLAND AND RIPARIAN RESOURCE MANAGEMENT

Lack of Adequate Baseline Information
Wetlands and riparian areas provide important plant and wildlife habitat for diverse species. They serve as nutrient sinks and play an important role in natural flood control. As landscape features, the Pecos River and Glorieta Creek floodplains provide vital links in interpreting the history and pre-history of the area.

Wetlands have not been well characterized within the park. The park-wide vegetation cover map (scale 1:10,000) is insufficient to delineate wetlands. It was derived from aerial photographs with limited field work (Rodriguez-Bejarano, 1992). Muldavin (1991) produced a map (scale 1:6,000) identifying fifteen plant and soil associations along a 2.5 mile segment of the Pecos River (Pecos Unit). While he categorized several palustrine wetlands within his study area, he did not classify riverine wetlands. Park staff are aware of several other seeps, springs and seasonally flooded areas that require documentation. There is limited information regarding wetlands or riparian areas along Glorieta or Galisteo Creeks.

Piecemeal wetland determinations in response to proposed development provide limited information on the extent, condition and significance of this scarce resource. Inadequate identification of wetlands prior to development could result in the degradation or destruction of important habitat. Delineation of wetlands and riparian areas throughout the entire park would assist managers in siting facilities and managing visitor use to avoid affecting sensitive plant and wildlife species.

Recommendations:

A thorough inventory of riparian areas and wetlands would be beneficial to the management of these important natural resources and should be completed as part of initial park inventory activities. The inventory should include:

- wetlands classifications (NWI) and mapping;
- documentation of plant and animal species distribution;
- identification/mapping of habitat suitable for sensitive plant and animal species;
- evaluation of stand health and species identification of cottonwoods;
- documentation of beaver herbivory; and,
- identification and population status of alien species.

This issue is addressed in Project Statement PECO-N-002.006 (Appendix A).

Wetland and Riparian Area Management

Human activities have significantly damaged riparian areas along the Pecos River. In upstream areas, grazing activities have caused severe erosion along Glorieta Creek. Downcutting has incised a deep channel throughout much of its length, preventing establishment of riparian vegetation.

Past land-use practices at the Forked Lightning Ranch include horse and cattle grazing, vehicle use on dirt roads along the Pecos River, and limited agricultural and recreational use. Bulldozers were used to maintain dirt roads, pastures, and river crossings (Muldavin, 1991). Since 1991, the National Park Service has eliminated stock grazing, agriculture and recreational use. However, continued use of dirt roads adjacent to the Pecos River and through poorly drained, low-lying areas may alter drainage patterns, cause erosion, crush vegetation, and affect wildlife habitat.

Future recreational use within the Pecos Unit is likely to concentrate within the riparian zone. The Pecos River upstream in the Santa Fe National Forest is the second most heavily fished river in New Mexico (Bruce Simms, Santa Fe National Forest, pers. comm.). There is growing pressure by anglers for access to the river in the park. Gains made in the natural recovery of riparian species, particularly cottonwoods, are likely to be affected if recreational users destroy young plants or trample fragile riverbanks. The General Management Plan, currently being drafted, will determine the types and levels of use appropriate for various zones within the park.

Muldavin (1991) and Witham (1993) noted that cottonwood stands along the Pecos River consist primarily of mature and over-mature trees, being 100 to 150 years of age. There are no intermediate-aged stands, and large trees "perched" above the normal high water line are dead or dying. Muldavin speculated that trampling, erosion and browsing by cattle severely reduced the vigor of the cottonwood population. Beaver may also have damaged young stands. Root suckering appeared to be the only reproduction occurring.

The previous owner wrapped the base of cottonwoods with chicken wire to prevent beaver herbivory. As the trees increase in diameter, the cages may girdle them. Removal of the cages would increase the value of this area as beaver habitat. While beaver may remove large, old trees,

their activity (particularly dam construction) will raise water levels, increase cottonwood reproduction through stump suckering, and improve habitat for other wildlife, cottonwood seedling growth, and hydrophytic plants. Consequently, in 1994 the park removed approximately one-third of the wire cages with the objective to allow for a more natural rate of beaver herbivory. Herbivory rates will be monitored in the future. The level of herbivory will assist management in determining if further wire removal is needed to attain a more natural mixed-age stand.

The status of alien tree, grass and forb species has not been determined. Small populations of tamarisk, red ash, apple and Russian olive grow on the floodplain along the Pecos River (Muldavin, 1991). Siberian elms planted at the Trading Post disperse their seeds to the Glorieta Creek streambanks (Bobbi Simpson, Pecos National Historical Park, pers. comm.). Tamarisk can rapidly colonize well-watered areas. Its high evapotranspiration rate can be a factor in lowering water-table levels. The elimination of stock use may increase seedling survival. Information on population and reproductive status of alien species is vital so that park personnel can develop and implement reduction strategies.

Recommendations:
The recommended activity is to manage riparian areas and wetlands to restore and preserve their natural function and integrity. In addition, it should be noted that wetlands currently existing due to man-induced activities are also regulated by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act. A primary objective should be to maintain the value of these rare southwestern resources for interpreting the area as a cultural crossroads, and to maintain increasingly precious plant and wildlife habitat. The types and levels of recreational use should be carefully managed based on a determination of carrying capacity appropriate to accomplish these objectives.

Management activities may include:

- monitoring riparian community structure and composition to document natural recovery;
- initiating research to determine limits of acceptable change for human use;
- limiting vehicle access to non-riparian routes;
- allowing and monitoring beaver herbivory; and,
- removing alien species.

These recommended activities will be addressed further in Project Statement PECO-N-002.006 (Appendix A).

WATER RIGHTS, WATER QUANTITY, AND RESERVOIRS

Water Rights

One of the wells currently used to support park operations is recorded in the State Engineer's Office. The National Park Service presently has only limited information on water use from nine additional wells within the park. In the Glorieta Unit, existing dwellings probably have small

domestic and stock wells which may or may not be recorded with the State Engineer's office. As these facilities are acquired, existing water rights associated with them would also be acquired. More research is needed to determine the number of existing wells in this unit and which are recorded with the State Engineer's office.

Recommendations:
The park should conduct a full inventory of water rights, quality and supply. This includes:

- updating well permits and records with the State Engineer's Office as necessary;
- assembling descriptive information on all wells and springs (location, depth, date installed, purpose and amount of past water use);
- determining the purpose and amount of future water use for each well and spring;
- if appropriate, abandoning wells according to State of New Mexico regulations;
- if appropriate, filing for additional water rights with the State Engineer's Office;
- checking newly inventoried or acquired areas for accompanying water rights;
- assembling descriptive information on the Pecos River diversion (old mill/agricultural irrigation ditches), reservoirs, Trading Post spring pond, and Ranch House cistern (location, storage/ditch size, date installed, purpose and amount of past water use);
- determining purpose and amount of future water use for the Pecos River diversion (old mill/agricultural irrigation ditches), reservoirs, Trading Post spring pond, and Ranch House cistern;
- determining future actions and time frames necessary for maintaining water rights; and,
- determining feasibility and/or appropriateness of purchasing water rights or converting existing water rights to protect instream flows.

The Water Rights Branch of the Water Resources Division provides technical support for water rights adjudications and works with the Office of the Solicitor and Department of Justice attorneys who represent NPS interests in developing litigation strategies. In addition, they may be able to provide guidance to the park in meeting the necessary filing requirements for the use of surface and groundwater within the park.

Water Quantity
Current documented water sources within authorized park boundaries include: three water courses (Pecos River, Glorieta Creek, Galisteo Creek), ten wells, and five springs. As lands within the Glorieta Unit are acquired and the eastern section of the Pecos Unit is inventoried, it is likely more wells and springs will be found. The U.S. Geological Survey collects discharge data from the Pecos River from a gaging station 9 miles above the town of Pecos. No flow data is recorded or available for Glorieta Creek, Galisteo Creek or for any of the identified wells or springs within the

park. The effect of water withdrawals on the park's water-related resources is unknown. Potential major developments near the park could have a significant affect on local water tables.

Recommendations:
The park should remain aware of proposed or potential land-use changes which could radically alter future water demands on local water sources. A complete field inventory of wells and springs in the Pecos Unit and in both sub-units of the Glorieta Unit is needed. The inventory should include legal descriptions, mapping, and development of a water source theme in the park's GIS program. Flows should be monitored to collect data on water quantities in Glorieta Creek and flow estimates calculated on the Pecos River from the gaging site 9 miles north of the park. Water levels and flows in known wells and springs also need to be monitored and records maintained.

This issue is addressed in Project Statement PECO-N-005.007 (Appendix A).

Reservoirs
Some action should be taken soon to avoid a catastrophic failure of the Glorieta Creek Reservoirs. The lower dam has been breached and the upper could fail with the next large flood event. The reservoirs also occupy an area that could be a valuable floodplain and wetland along Glorieta Creek.

Impacts to park resources from water backed up into the park from an impoundment south of the ranch include inundation of about 240 acres, loss of perennial plants over most of that area, and creation of conditions that foster exotic weeds. It predates National Park Service ownership and may fall under a deed condition for acceptance of pre-existing conditions. Legal status should be explored, but considering other issues facing the park, this would be a relatively low priority.

Recommendations:
The recommended course of action to mitigate impacts of the two reservoirs on Glorieta Creek is to: (1) construct a temporary barrier at the point of diversion to prevent water from entering the upper reservoir; (2) determine legal status of the water rights; and (3) develop a plan for reconstruction and long-term maintenance of these reservoirs, or remove them and restore to a more natural floodplain. Any plans to maintain the reservoirs should include structures to control the inflow and stable spillways.

The historic significance of the pond at Trading Post Spring and associated developments should be explored. Interim management should include maintenance of the dam and fish screen. This issue will be addressed in Project Statement PECO-N-015.001 (Appendix A).

EROSION

The condition of watersheds both in and upstream of the park are of great concern. The age of trees growing in the bottom of major gullies demonstrate that gully erosion has been occurring in the past 50 to 200 years. Possible causes in this time window are past grazing, sand and gravel removal from Glorieta Creek, road and railroad construction, timbering, and possibly even fire suppression (Bruce Simms, Santa Fe National Forest, pers. comm.).

The development of the type of gully erosion found in the park usually follows a typical pattern. Disturbance on a watershed or in a channel causes instability and results in local gullying. These gullied areas will often recover unless the disturbance continues, in which case gullies expand until they are extensive. Large events (such as a flood) can also cause widespread gullying in a destabilized drainage system. Effects can be greater when the channels are unstable, and grazing, paving or timbering activities occur in the watershed. Once a major channel begins to incise, it lowers the base level for all tributary channels and causes gullies to proceed up those channels. The gullies continue to expand until a new equilibrium is reached between water, sediment supply, and bed stability. In some cases, channels can aggrade back toward the original base level, but most frequently, the channel remains lower for a long period.

In general terms, success in the control of gully erosion is mixed. The best results have been obtained when an entire watershed is treated. Some success has also been achieved treating first and second order channels with various structures or soil treatments.

The predominant erosion in the park occurs on the Glorieta Creek watershed. This reduces the potential land productivity and could damage historic and archaeologic resources. Gullies and headcuts initiated by past erosion on Glorieta Creek are observed to be gradually advancing up tributary watersheds.

Treating erosion throughout the park is not a practical alternative at this time. The long-term stability of Glorieta Creek is largely dependent on actions occurring throughout the watershed in many areas beyond park control. In addition, Glorieta Creek appears to have established some stability at a new base level, 10 to 20 feet below the original. Restoring the original base level is not practical because of the amount of material removed from the system and the disruption it would cause. The best treatment to restore productivity to the creek and its floodplain is to allow the natural recovery process to continue.

Recommendations:
The recommended action is to inventory and establish priorities for addressing park erosion problem areas. Upon completion of the inventory, critical erosion areas should receive treatment to prevent the continued advancement of headcuts into sensitive resources with installation of erosion control structures, recontouring, and revegetation. Soil stability should be part of an erosion inventory and any program to monitor range recovery. If soils do not stabilize rapidly, other methods including seeding, prescribed burning, and soil stabilization should be explored.

This issue will be addressed in Project Statement PECO-N-005.008 (Appendix A).

OTHER WATER RESOURCE ISSUES

Illegal Dumps
When the park was acquired, there were a number of illegal and informal dump sites located on the property. The major and most obvious sites have been cleaned up but a number of miscellaneous sites still remain and may be impacting water quality. These sites include a number of locations along La Joya Road and sporadic smaller sites across the Pecos Unit. Items of concern include household waste, automobiles, petroleum products, and miscellaneous materials.

Recommendations:
An inventory and cleanup activities for these sites should be implemented.

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APPENDIX A

Proposed Water Resource-Related Project Statements

PECO-N-002.005	Inventory Aquatic Biological Resources and Fisheries
PECO-N-002.006	Conduct Comprehensive Wetlands and Riparian Inventory
PECO-N-005.006	Water Quality Condition Assessment/Standards Evaluation
PECO-N-005.007	Inventory and Monitor Water Resources - Quantity
PECO-N-005.008	Inventory Watershed Condition - Erosion
PECO-N-005.009	Monitor Pecos River and Glorieta Creek Water Quality
PECO-N-015.002	Evaluate Glorieta Creek Reservoir Removal/Restoration

PROJECT STATEMENT SHEET

Project Number: PECO-N-002.005

Last Update: 07/07/95 Priority: 16
Initial Proposal: 1995

Title: INVENTORY AQUATIC BIOLOGICAL RESOURCES AND FISHERIES

Funding Status: Funded: $0.0K Unfunded: $100.0K

Servicewide Issues: N00 (FISHERIES)
N20 (BASELINE DATA)

RMAP Program Codes: W08 (FISHERIES MANAGEMENT)
Q01 (WATER RESOURCES MANAGEMENT)

PROBLEM STATEMENT

There is a lack of information regarding the aquatic biological resources and fisheries of Pecos National Historical Park. The park staff has only a basic knowledge of fish species composition within its two main water courses, the Pecos River and Glorieta Creek, and only a limited knowledge of habitat characteristics, stream morphology, benthic macroinvertebrates or other aquatic biological resources. Consequently, the appropriate long-term management of the park's aquatic biological resources will require a more definitive inventory of aquatic biological resources supported by a periodic monitoring program, especially as park visitation and resource utilization increase with the opening of the former Forked Lightning Ranch to public visitation.

Six fish species are known to exist in the Pecos River within Pecos National Historical Park. Two of the species, brown and rainbow trout (*Salmo trutta* and *Oncorhynchus mykiss*), are non-native species which ultimately may be subject to increased recreational fisheries pressure. A "put and take" fishery in the Pecos River above the park is the second busiest fishing locale in the state. The native fish of the Pecos River include the white sucker (*Catostomous commersoni*), fathead minnow (*Pimephales promelas*), longnose dace (*Rhinichthys cataractae*), and Rio Grande chub (*Gila pandora*). The lower portion of Glorieta Creek within Pecos National Historical Park is known to contain all of the above, except the rainbow trout. In addition, recent information suggests some of these species contained elevated levels of heavy metal contaminants, probably associated with historic upstream mining and ore processing activities (Irwin, 1993; 1994).

An inventory and monitoring program is needed to address these aquatic resource management issues:

- response of fisheries and aquatic biological resources to potential recreational fishing and fish stocking programs;

- response of fisheries and aquatic biological resources to potential human-induced activities occurring inside the park and from sources upstream;

- provide baseline data for effective visitor use planning (e.g., placement of visitor facilities, design of interpretive and hiking trails, etc.) and for assessment of potential impacts from routine park maintenance;

- provide baseline data to predict changes in biological diversity, species composition, and relative abundances of aquatic organisms in response to natural causes (e.g., floods, droughts, etc.) and human-induced events (e.g., previous grazing, prescribed natural fires, and other land-use activities); and,

- monitor contaminants in fish tissues, coordinate these activities with the New Mexico Department of Game and Fish, and assess the potential risks to park visitors and wildlife.

The park is undertaking a limited water quality monitoring program on the Pecos River and Glorieta Creek. The park is also presently cooperating with the New Mexico Department of Game and Fish in a study of the reproductive biology of the Rio Grande chub. The study will provide useful habitat information in lower Glorieta Creek (Pittenger, 1993). In addition, a study of water quality and several biological indicator species is expected to begin in 1995 (Jacobi, 1995).

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY

A multi-year aquatic biological resources and fisheries inventory program is recommended. The project should:

- compile information on past aquatic resources and fisheries management activities conducted by the NPS, New Mexico Department of Game and Fish, and/or other management authorities within the Pecos River and Glorieta Creek watersheds;

- produce a channel morphology map through field inventory and ground truthing and employ techniques to compare to earlier research conducted on the Pecos River in Santa Fe National Forest upstream from the park;

- develop a basic inventory of fisheries and aquatic benthic macroinvertebrate resources that incorporates assessments of stream habitat, biological diversity, community composition, relative species abundance, and overall productivity; and,

- monitor contaminants in fish tissues, coordinate these activities with the New Mexico Department of Game and Fish, and assess the potential risks to park visitors and wildlife.

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BUDGET AND FTEs

FUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
			Total:	0.0	0.0

UNFUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
Year 1		RES	O	30.0	0.2
		MON	R	10.0	0.1
			Subtotal:	40.0	0.3
Year 2		RES	O	30.0	0.2
		MON	R	10.0	0.1
			Subtotal:	40.0	0.3
Year 3		RES	O	10.0	0.1
		MON	R	10.0	0.1
			Subtotal:	20.0	0.2
			Total:	100.0	0.8

Compliance codes: EXCL (CATEGORICAL EXCLUSION)
Explanation: 516 DM2 App. 1.6

PROJECT STATEMENT SHEET

Project Number: PECO-N-002.006

Last Update: 07/07/95 Priority: 7
Initial Proposal: 1995

Title: CONDUCT COMPREHENSIVE WETLANDS AND RIPARIAN INVENTORY

Funding Status: Funded: $1.0K Unfunded: $23.0K

Servicewide Issues: N17 (BIODIVERSITY)
N20 (BASELINE DATA)

RMAP Program Codes: Q01 (WATER RESOURCES MANAGEMENT)
E00 (ENVIRON PLNG and COMPLIANCE)

PROBLEM STATEMENT

Wetlands and riparian areas are some of the most productive and significant natural resources at Pecos National Historical Park. Baseline information is needed to manage development and human activities that may adversely affect these areas, which are recovering from past uses such as livestock grazing and agriculture.

Wetlands have not been well characterized within the park. The park-wide vegetation cover map (scale 1:10,000) is insufficient to delineate wetlands. It was derived from aerial photographs with limited field work (Rodriguez-Bejarano, 1992). Muldavin (1991) produced a map (scale 1:6,000) identifying fifteen plant and soil associations along a 2.5 mile segment of the Pecos River (Pecos Unit). While he categorized several palustrine wetlands within his study area, he did not classify riverine wetlands. Park staff are aware of several other seeps, springs, and seasonally flooded areas that require documentation. Only very broad scale information is available for wetlands or riparian areas along Glorieta or Galisteo Creeks.

Case-by-case wetland determinations in response to proposed development provide limited information on the extent, condition, and significance of this regionally scarce resource. Inadequate identification of wetlands prior to development could result in the direct destruction of important habitat. Indirect impacts include petroleum, salt or lead contaminated runoff from parking lots and roads, and toxic runoff affiliated with non-point dumping on La Joya Road.

A wetland and riparian map is needed for the entire park, particularly Glorieta and Galisteo Creeks. Inventories of flora (species composition and structure) and fauna (small mammals, reptiles, amphibians, birds) within wetland/riparian habitats are inadequate to determine the presence of at least seven sensitive species that may occur. Identification of habitat critical to federally or state protected species would help managers mitigate potential impacts of recreational use and development.

Expansion of the park has resulted in changes in land-use practices at the Forked Lightning Ranch. Thorough documentation of wetlands and riparian areas will provide a foundation for measuring changes in the future. A mapping and inventory effort will serve resource management by:

- determining response of wetlands and riparian zones to removal of stock use;
- recognizing changes in riparian and wetland boundaries due to recreational use, vegetation management, and other management practices;
- providing baseline for effective visitor use planning (e.g., design and placement of visitor facilities);
- providing information to manage the overall landscape to maintain a visual context for interpreting the cultural history of the park; and,
- understanding and predicting changes in wetland boundaries and community structure in response to natural and human induced factors.

The inventory will provide the basis for developing monitoring plans to track natural processes and changes. Coupling the wetland and riparian zone assessment with aquatic surveys, water quality monitoring, and vegetation and wildlife surveys will provide many of the data sets necessary for managers to make well-informed resource protection decisions.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY

A one-year wetland mapping and assessment program is recommended. Two phases include wetland/riparian zone mapping and field inventory/assessment.

The first phase includes:

- determining and assigning appropriate National Wetland Inventory (NWI) categories to Muldavin's (Muldavin, 1991) riparian wetland areas; and,
- producing a large scale (perhaps 1:1,500) digital wetland map based on available aerial photography (1:6,000) and park-wide vegetation map (1:10,000). The NWI classification scheme should be adopted.

Activities included in the second phase are to:

- Interview park employees and local residents to determine the location of springs and other water sources that may support wetlands. Some of these may be too small to appear on aerial photographs.
- Conduct a detailed field inventory. The field team should determine soil types, water table levels, and water sources, and produce comprehensive plant and animal species lists for each wetland and riparian area. Special emphasis should be placed on identifying

populations and critical habitat for rare or sensitive species (e.g., southwestern willow flycatcher, bald eagle, peregrine falcon, gray vireo, Say's pond snail, meadow jumping mouse, giant helliborne orchid). Populations of hybrid lanceleaf cottonwoods, along with the two species from which they originate, also should be mapped. The survey should encompass all seasons.

The final report should include maps of the park with wetland types, riparian areas, and cottonwood populations identified. Alien tree and shrub species also should be delineated. A written description for each wetland type and riparian area, identifying species composition, soil types, and hydrological regimes will be particularly useful to park managers.

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BUDGET AND FTEs

FUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
1995	PKBASE-NR	ADM	O	1.0	0.1
			Total:	1.0	0.1

UNFUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
Year 1		MON	O	23.0	0.5
			Total:	23.0	0.5

Compliance codes: EXCL (CATEGORICAL EXCLUSION)
Explanation: 516 DM2 App. 1.6

PROJECT STATEMENT SHEET

Project Number: PECO-N-005.006

Last Update: 06/27/95 Priority: 0
Initial Proposal: 1994

Title: WATER QUALITY CONDITION ASSESSMENT/STANDARDS EVALUATION

Funding Status: Funded: $70.0K Unfunded: $0.0K

Servicewide Issues: N11 (WATER QUAL-EXT)

RMAP Program Codes: Q01 (WATER RESOURCES MANAGEMENT)

PROBLEM STATEMENT

Pecos National Monument was originally established in 1965 as a unit of the National Park System to "preserve for the benefit and enjoyment of the American people a site of exceptional historical and archeological importance" (P.L. 89-54). In 1990 Congress passed two bills (P.L. 101-313 and 89-54) which increased the park land base from 365 to 6,670 acres and redesignated the Monument as Pecos National Historical Park. The new legislation recognized the park's "multi-theme history" as well as providing for "...the preservation and interpretation of the cultural and natural resources..." (P.L.101-313).

Water resources and riparian environments are critical components of the cultural landscape and important natural resources of Pecos National Historical Park. Culturally, the presence and location of a reliable water source, such as the Pecos River or Glorieta Creek, was a major factor in the history and pattern of settlement within the region. Land use was further influenced by the river's small floodplain which offered the opportunity for agricultural activity and produced a stimulus for prehistoric and historic trade (National Park Service, 1993). From the natural resource perspective, waters within Pecos National Historical Park support populations of brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*), and a number of native fish species including the Rio Grande chub (*Gila pandora*), longnose dace (*Rhinichthys cataractae*), white sucker (*Catostomous commersoni*), and fathead minnow (*Pimephales promelas*). In addition, the Pecos River and Glorieta Creek support significant riparian wetlands, a rare resource in the American Southwest, which provide important habitat for wildlife and migratory birds (Muldavin, 1991).

The Pecos Unit of the park contains a 3.1 mile segment of the Pecos River, and the lower 3.5 miles of Glorieta Creek, a perennial tributary to the Pecos River. The Glorieta Unit of the park includes a 0.9 mile reach of Glorieta Creek, and a 0.5 mile reach of Galisteo Creek. River and creek reaches within the park are potentially influenced by the following upstream land-use activities:

- effluent discharged by the Village of Pecos Wastewater Treatment Facility and the Glorieta Conference Center, both National Pollution Discharge Elimination System (NPDES) permitted sewage treatment facilities;

- contaminants associated with abandoned mines (Tererro Mine) and mill tailings (El Molino Mill site);

- nutrient loading and bacterial contamination from poorly designed or poorly located septic systems;

- non-point source pollution from adjacent streamside development (residential, agricultural, and commercial); and,

- suspected contamination from illegal dumping.

The NPS Water Resources Division conducted an assessment of available water quality information for the Pecos River which indicated that while a moderate amount of water quality inventory and monitoring activities had been conducted by the New Mexico Environment Department and USDA - Forest Service in the upper headwaters of the Pecos River, little water quality information was available for the Pecos River below the village of Pecos or within Pecos National Historical Park. This is significant because effluent from the Village of Pecos Wastewater Treatment Facility, located approximately 2 miles above Pecos National Historical Park, failed to meet NPDES permit requirements for BOD (biological oxygen demand), pH, or fecal coliform bacteria 14 times in 1993 (New Mexico State University, 1994). During one of these periods (June/July, 1993) a significant fish kill occurred in the Pecos River downstream from the Village of Pecos Wastewater Treatment Facility (Easthouse, 1993). The impact of this facility on park resources is unknown at this time.

A review of available water quality information indicated that with the exception of limited effluent compliance monitoring at the Glorieta Conference Center Wastewater Treatment Facility, little water quality inventory or monitoring information is available for Glorieta Creek (National Park Service, 1994). During a site visit to Pecos National Historical Park by the NPS Water Resources Division, Long (1992) noted the frequent occurrence of noticeable amounts of green filamentous algae throughout the lower reach of Glorieta Creek, a situation often indicative of excessive nutrient loading.

The New Mexico Water Quality Control Commission has established limited water quality standards for the Glorieta Creek and the in-park reach of the Pecos River (New Mexico Water Quality Standards Section 2213). These limited standards likely do not fully protect park values. However, the New Mexico Water Quality Standards also provide for an "antidegradation policy" developed to prevent degradation of high quality waters of designated "... national and state monuments, parks, and wildlife refuges ... if such degradation would impair any of the qualities which caused designation of these waters, parks, and wildlife refuges" (New Mexico Water Quality Standards Section 1101.A).

In light of the 1990 park expansion which incorporated significant reaches of the Pecos River and Glorieta Creek into a unit of the National Park System, the adequacy of current designated use classifications, and the protection of park waters under New Mexico's "antidegradation" policy

need to be addressed. More explicitly, numerical water quality criteria need to be developed, proposed and monitored to provide appropriate "antidegradation" protection.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY

The goals relating to the management of water resources at Pecos National Historical Park are two-fold. The first goal is to implement water quality inventory and monitoring activities necessary to understand and manage water-related resources adequately. The implementation of the first goal will aid the park in its second goal, to work with state regulatory agencies towards the promulgation of water quality standards that simultaneously will protect existing high quality waters while working to improve water quality conditions in those areas where degradation currently occurs.

The objectives of this project are to:

- conduct a "reach-by-reach" water quality condition assessment in segments of the Pecos River and Glorieta Creek immediately above and within Pecos National Historical Park to inventory existing water quality conditions, and to identify sources and magnitude of water quality degradation; and,

- establish Pecos River and Glorieta Creek water quality baselines to substantiate the development of anti-degradation water quality criteria.

Four complementary components will be undertaken as part of this study:

- a two-year intensive inventory of water quality conditions at five sites in the Pecos River extending from immediately upstream of the Village of Pecos Wastewater Treatment Facility (WWTF) to just below the confluence with Glorieta Creek;

- a two-year intensive inventory of water quality conditions in Glorieta Creek at six sites extending above the Glorieta Conference Center Wastewater Treatment Facility to the boundary of Pecos National Historical Park;

- the establishment of a database adequate to develop proposed "antidegradation" water quality criteria for the Pecos River and Glorieta Creek; and,

- cooperation with a New Mexico Department of Game and Fish fisheries habitat assessment in lower Glorieta Creek.

Water quality information and assessments obtained from this study will be used to: 1) establish a water quality/aquatic resources baseline; 2) identify sources of water quality degradation on a reach-by-reach basis; 3) serve as a basis for developing and proposing more protective water quality standards (in accordance with NPS and State of New Mexico policies); and, 4) provide the background information necessary for New Mexico Environment Department/NPS cooperation in mitigating existing water quality-related problems.

The two-year intensive studies in the Pecos River and Glorieta Creek would be conducted by a NPS cooperator in accordance with a study plan developed jointly by the cooperator, the NPS Water Resources Division and Resource Management staff at Pecos National Historical Park. The proposed water quality condition assessment would focus primarily on potential water quality problems associated with effluent discharge into the Pecos River (Village of Pecos WWTF) and Glorieta Creek (Glorieta Conference Center WWTF), and non-point source pollution from poorly designed and/or poorly located septic systems, adjacent streambank development, and illegal dumping. Contaminant issues associated with tailings ponds at the inactive Tererro Mine and El Molino Mill Site are beyond the scope of this study, and are being addressed separately by Cyprus AMAX Minerals Company and the State of New Mexico (AMAX, Inc. 1993).

The proposed study would consist of the sampling, analysis, and interpretation of monthly water quality data including instantaneous discharge, water temperature, pH, dissolved oxygen, specific conductance, turbidity, total suspended solids, soluble reactive phosphorus, nitrate-nitrogen, ammonia-nitrogen, and total nitrogen as well as seasonal assessments of benthic macroinvertebrates, quantification of filamentous algae biomass and distribution, and diurnal dissolved oxygen studies. The study plan will also contain a design for occasional event-related bacterial contamination surveys.

Database development would be undertaken by the NPS cooperator in consultation with a statistician familiar with the analysis of water quality data by non-parametric statistical techniques so that the data derived in this study can be used as a basis for water quality criteria development.

LITERATURE CITED

AMAX, Inc. 1993. El Molino Operable Unit site characterization and reclamation plan for the Alamitos Canyon tailing areas near Pecos, New Mexico. Golden, Colorado.

Easthouse, K. 1993. Pecos sewage plant blamed for death of fish. The New Mexican, July 14, 1993. Santa Fe, New Mexico.

Long, B. 1992. Memorandum to the Chief, Water Resources Division, National Park Service from the Hydrologist, Water Operations Branch entitled "Trip report for travel to Pecos National Historical Park on July 21-23, 1992." September 18, 1992. Fort Collins, Colorado: National Park Service. 4 pp.

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National Park Service. 1993. Land protection plan, Pecos National Historical Park - Glorieta Unit. Santa Fe, New Mexico: Southwest Regional Office; and Pecos, New Mexico: Pecos National Historical Park. 25 pp.

Pittenger, J. 1993. Proposal, Rio Grande chub, *Gila pandora* (Cope), life history study. Santa Fe, New Mexico: New Mexico Department of Game and Fish. 5 pp.

New Mexico State University. 1994. New Mexico 104(g) diagnostic evaluation report for the Village of Pecos Wastewater Treatment Facility. Santa Fe, New Mexico: New Mexico State University, Water Utilities Technical Assistance Program. 3 pp.

BUDGET AND FTEs

FUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
1995	WATER RES	RES	C	25.0	0.1
	PARK-NR	RES	C	15.0	0.1
1996	WATER RES	RES	C	15.0	0.1
	PARK-NR	RES	C	15.0	0.1
			Total:	70.0	0.4

UNFUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
			Total:	0.0	0.0

Compliance codes: EXCL (CATEGORICAL EXCLUSION)
Explanation: 516 DM2 App. 1.6

PROJECT STATEMENT SHEET

Project number: PECO-N-005.007

Last Update: 06/27/95 Priority: N/A
Initial Proposal: 1995

Title: INVENTORY AND MONITOR WATER RESOURCES - QUANTITY

Funding Status: Funded: $0.0K Unfunded: $41.0K

Servicewide Issues: N13 (WATER RIGHTS)
N20 (BASELINE DATA)

RMAP Program Codes: Q02 (WATER RIGHTS MANAGEMENT)

PROBLEM STATEMENT

The quantity, legal status, and use of water available from sources within or available to Pecos National Historical Park is only partially documented. Water resources within authorized park boundaries include: three water courses (Pecos River, Glorieta Creek, Galisteo Creek), ten wells, and five springs. As lands within the Glorieta Unit are acquired and the area east of the Pecos River in the Pecos Unit is inventoried, the number of known wells and springs is likely to increase. The U.S. Geological Survey collects Pecos River discharge data from a gaging station 9 miles above the village of Pecos. No flow data are recorded or available for Glorieta or Galisteo Creeks, or for any of the identified wells or springs within the park.

Additionally, the park has incomplete information as to the status of water rights in the park. Two of the ten wells located within the expanded boundaries of the park have been recorded in the State Engineer's Office. Registration of older wells/spring sources on the Forked Lightning Ranch may not have been required when these well/spring sources were first appropriated. The park should focus efforts on defining and gathering evidence relating to the appropriation (i.e., records of times and amounts of water use) and beneficial uses (i.e., what was done with the water).

To properly manage these various water sources, the park should determine the historic and future purpose and volume of water use from these sources. Once this information is established, the NPS can analyze existing water rights to determine what, if any, water right changing/filing should be undertaken.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY

The following projects/activities will be accomplished through a combination of contract(s) with a subject-area specialist(s) and use of in-house park resources.

- Conduct a comprehensive inventory of wells and springs in the park; map and add to the park's GIS database. Gather and document any available information regarding historic, present, and intended volume and timing of water use from these sources.

- Determine legal descriptions (location) of all water sources. Document the sources on maps and aerial photographs.

- Develop and implement an ongoing program to monitor discharge in Glorieta Creek. The park also should develop a database of estimated flow in the Pecos River at the boundary of Pecos National Historical Park by modifying discharge measurements taken by the U.S. Geological Survey 9 miles above the park.

- Develop and implement an ongoing program to monitor, record, and maintain records of water flows/levels in known wells and springs.

- Develop and implement an ongoing program to maintain a record of water use from wells and springs.

BUDGET AND FTEs

FUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
			Total:	0.0	0.0

UNFUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
Year 1		INV	O	15.0	0.7
	PK-BASE	MON	R	4.0	0.1
Year 2		INV	O	10.0	0.4
	PK-BASE	MON	R	4.0	0.1
Year 3	PK-BASE	MON	R	4.0	0.1
Year 4	PK-BASE	MON	R	4.0	0.1
			Total:	41.0	1.5

Compliance codes: EXCL (CATEGORICAL EXCLUSION)
Explanation: 516 DM2 App. 1.6

PROJECT STATEMENT SHEET

Project Number: PECO-N-005.008

Last Update: 06/28/95 Priority: N/A
Initial Proposal: 1995

Title: INVENTORY WATERSHED CONDITION - EROSION

Funding Status: Funded: $0.0K Unfunded: TBD

Servicewide Issues: N06 (LAND USE PRAC)

PROBLEM STATEMENT

Watersheds in and near the Pecos National Historical Park have been subjected to severe erosion. The condition of watersheds in and upstream of the park is of great concern. The age of trees growing in the bottom of the major gullies shows that erosion has occurred in the past 50 to 200 years. Possible causes are past grazing activities, sand and gravel mining, road and railroad construction activities, logging, and fire suppression (Bruce Simms, Santa Fe National Forest, pers. comm.).

Gully, sheet, and rill erosion is evident over large areas of the park, particularly the Glorieta Creek watershed. A survey of aerial photographs shows that nearly all of the perennial and ephemeral channels in the lower one third of the watershed are entrenched, including those in the park. The main channel of Glorieta Creek appears to have stabilized where it is entrenched. The entrenchment is estimated to be 10 to 20 feet over much of the creek's length, and in many places has been lowered to bedrock. Tributary channels are gullied though usually not as deep. Gully systems are continuing to expand up several tributaries into upland areas. This expansion will continue until the incised channels stabilize and banks are eroded back to a more stable slope. The lack of an erosional inventory makes it difficult for management to adequately assess and address impacts.

Continued erosion will result in the mobilization and transport of large amounts of soil. Given the amount of historic and prehistoric occupation of this area, numerous sites and artifacts are threatened by the advance of erosion. A survey of watershed conditions should be concurrent with an archaeological survey and mapping of the park.

Erosion control structures are not practical in Glorieta Creek and larger tributary canyons because they will be prone to washing out, and only a small portion of the watershed can be treated inside the park. The larger channels also appear to be trending toward greater stability. Rehabilitation of these channels is needed to establish healthy riparian vegetation and improved ground cover conditions on the watershed.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY

The most effective action to control accelerated erosion, the removal of livestock grazing, has been taken already. Future efforts will focus on controlling localized erosion where high value resources are threatened. These include areas with deep soils, wetlands and springs, and archaeologic and historic sites.

Control efforts may include erosion control structures, recontouring, seeding or planting. It will be important to monitor the effect of the land use change in the park so that appropriate and cost effective measures can be undertaken to control future erosion.

Erosion problems will be mapped and evaluated in all areas of the park over a two-year period, and sites will be stabilized where significant natural or cultural resources are threatened. Specific steps would include:

Year 1:

- Conduct a preliminary survey of past aerial photographs to identify the most significant areas of active erosion.

- Complete a ground survey and mapping of all problem areas in a manner compatible for entry into a GIS system.

- Evaluate erosion threats as part of an archaeological survey.

- Utilizing GIS technology, compare actively eroding sites with archeological, historic and sensitive natural resource GIS data layers to identify threatened and/or priority areas.

- Develop design "blueprints" for mitigative measures for addressing the highest priority erosion problem areas where suitable.

Year 2:

- Secure necessary funding and implement erosion control efforts in priority order.

- Establish appropriate monitoring network in known areas of threat and resource sensitivity to identify baseline conditions, monitor, and calculate rates of erosion.

Funding will be sought for erosion stabilization under the reasonable assumption that resource threats will be detected.

BUDGET AND FTEs

FUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
			Total:	0.0	0.0

UNFUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
Year 1		RES	O	30.0	0.3
Year 2		MIT	C	30.0	0.2
		MON	R	10.0	0.1
Year 3		MIT	C	TBD	TBD
		MON	R	5.0	0.1
Year 4		MIT	C	TBD	TBD
		MON	R	5.0	0.1
			Total:	TBD	TBD

Compliance codes: Initial Research/Inventory Phase - EXCL (CATEGORICAL EXCLUSION)
Explanation: 516 DM2 App. 1.6

Implementation of Mitigation Projects - EA/ARPA/NHPA may be required depending upon the individual circumstances.

PROJECT STATEMENT SHEET

Project Number: PECO-N-005.009

Last Update: Priority: N/A
Initial Proposal:

Title: MONITOR PECOS RIVER AND GLORIETA CREEK WATER QUALITY

Funding Status: Funded: $0.0K Unfunded: $50.0K

Servicewide Issues: N11 (WATER QUAL-EXT)
N20 (BASELINE DATA)

RMAP Program Codes:

PROBLEM STATEMENT

Water quality data exists on the Pecos River; however, much of the data has been collected upstream of the Pecos National Historical Park boundaries. There is an almost complete lack of baseline data regarding water quality for Glorieta Creek. Because the Pecos River and Glorieta Creek are the two main waterways running through the park, a good base of water quality data is essential to management for making long-term decisions regarding park resources.

The Pecos River arises in the Sangre de Cristo Mountains about 30 miles north of the park. It flows generally south/southeast for more than 900 miles and eventually empties into the Rio Grande near Del Rio, Texas. The Peco National Historical Park contains a 2.9 mile segment of the Pecos River and supports significant riparian wetlands which provide important habitat for wildlife and migratory birds.

The Pecos River is influenced by several upstream quality degrading sources that affect the river's water quality as it flows through the park. These include:

- The Tererro Mine. Located approximately 14 miles north of the park, this abandoned mine consists of numerous unstabilized spoil and overburden piles lying in Willow Creek, a tributary of the Pecos River. Elevated zinc, lead, copper, and cadmium levels have been observed in Willow Creek and the Pecos River below the mine site (Sinclair, 1990).

- El Molino Mill Site. This former mill site is located northwest of the village of Pecos on Alamitos Creek, a tributary to the Pecos River. The site consists of two large tailings ponds. A pond failure in 1973 allowed tailings dispersal downstream. Elevated levels of lead, cadmium, iron, and manganese have been found in Alamitos Creek below the site (Woodward-Clyde Consultants, 1989).

- Village of Pecos Wastewater Treatment Facility. This facility, operated by the Village of Pecos, is located along the Pecos River less than 2 miles above the north boundary of the

park. The facility provides secondary treatment for a peak summer use of 50,000-60,000 gallons per day. Based upon a recent assessment of the facility by New Mexico State University, the plant was found to be well operated, but is experiencing design-dependent compliance problems. These problems appear related to a significant increase in algal production, increasing TSS, and BOD_5 as wastewater flows through the facility (Haywood Martin/Robert Gott, New Mexico State University, pers. comm.).

- Village of Pecos Landfill. The Village of Pecos Landfill is located adjacent to Alamitos creek, a tributary to the Pecos River. Effects on water quality, if any, from landfill runoff or leachate are unknown.

- Other problems that have a potential impact on the Pecos River as it flows through the park are a contaminated Forest Service campground upstream, land-use practices, and erosion.

Glorieta Creek originates approximately 10 miles northwest of the park's Pecos Unit and only 6 miles northwest of the Pigeon Ranch portion of the Glorieta Unit of the park. Being downstream from the source, there are several potential outside influences which affect water quality before it enters the park. These include:

- The Glorieta Conference Center Wastewater Treatment Plant. This facility is located on-site at the conference center and services the needs of a compound which plays host to thousands on a yearly basis. The plant is permitted by the state and is required to test for quality on a regular basis. A recent check (March 1994) with the Surface Water Quality Bureau in the New Mexico Environment Department revealed the plant generally has had a good record of compliance, but that testing parameters do not include heavy metals. Discharge monitoring reports record that, since 1991, the plant has been out of compliance seven times, with irregularities brought up to standard within 24 hours.

- Numerous housing units. These exist upstream of the park within 100 yards to 0.5 mile (or closer) of the creek bank. Visual observations over the years have indicated that many of these sites have inadequate septic systems, open waste heaps, and outhouses. In some cases, residents may be dumping raw sewage directly into the waterway from these residences.

- Agricultural use upstream. This is crop and grazing related. Nutrient runoff takes place from commercial fertilizers and chemicals, and from animal waste. Based on visual evidence, these sources are believed to contribute to algal growth in the creek.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY

Pending completion of an initial inventory and water quality condition assessment (PECO-N-005.006), the development and establishment of a long-term water quality monitoring program for the Pecos River and Glorieta Creek is recommended. This would allow the park to establish baseline data for the waterway to aid in management planning and decision-making.

The monitoring program should include macroinvertebrates and algal species in the streambed. These should be checked on a semi-annual basis. Other parameters to be checked every quarter

should include total and dissolved metals (lead, iron, copper, nickel, zinc, manganese, and mercury), nitrogen, and total and dissolved phosphorus.

Parameters to be monitored on a quarterly basis should include TDS, BOD, pH, fecal coliform, dissolved oxygen, and oil/grease. Storm flow sampling (for parameters measured bi-monthly and bi-weekly) should be done as needed. This should be budgeted initially for three to four times per year. Once the water quality monitoring is funded, the park should request assistance from the National Park Service's Water Resource Division in finalizing testing parameters, sampling schedules, etc.

LITERATURE CITED

Sinclair, S. 1990. Screening site inspection of Tererro Mine, San Miguel County, New Mexico. Santa Fe, New Mexico: New Mexico Environmental Improvement Division. 17 pp.

Woodward-Clyde Consultants. 1989. Alamitos Canyon tailing dams near Pecos, New Mexico.

BUDGET AND FTEs

FUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
			Total:	0.0	0.0

UNFUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
Year 1	PK-BASE	MON		12.5	0.2
Year 2	PK-BASE	MON		12.5	0.2
Year 3	PK-BASE	MON		12.5	0.2
Year 4	PK-BASE	MON		12.5	0.2
			Total:	50.0	0.8

Compliance codes: EXCL (CATEGORICAL EXCLUSION)
Explanation: 516 DM2 App. 1.6

PROJECT STATEMENT SHEET

Project Number: PECO-N-015.002

Last Update: 06/12/95 Priority: 12
Initial Proposal: 1995
Page Number: 0009

Title: EVALUATE GLORIETA CREEK RESERVOIR REMOVAL/RESTORATION

Funding Status: Funded: $0.0K Unfunded: $65.0K

Servicewide Issues: N06 (LAND USE PRAC)
N13 (WATER RIGHTS)

RMAP Program Codes: Q01 (WATER RESOURCES MANAGEMENT)

Cultural Resource Type: CULL (CULTURAL LANDSCAPE)

PROBLEM STATEMENT

Glorieta Creek and its associated riparian zone have encountered significant human-related disturbance in the vicinity of the Trading Post. Two reservoirs, referred to as "upper and lower Glorieta Creek reservoirs," were constructed in the early 1980s on a floodplain east of the creek. Together they are capable of holding an estimated 90 acre feet of water. Both reservoirs fill during the spring rains and come close to drying out just prior to the late summer monsoon rains. The lower reservoir dam was breached prior to 1992 aerial photography. The upper reservoir dam nearly failed during the August, 1993 flood.

The scars and repercussions from the gravel mining have severely impacted the function of Glorieta Creek. Currently, the reservoirs have created an artificially manipulated environment. The cultural and natural resource implications of these reservoirs, the severity of their impacts on stream and riparian zone ecology, and the desirability of various restoration alternatives should be assessed.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY

The recommended actions include:

- researching the water rights associated with the reservoirs;
- documenting the relative health and sustainability of the existing riparian corridor; and,
- developing a management plan which fosters sustainability.

Existing impacts need to be understood more fully. Baseline information on the stability of the Glorieta Creek course, the quality of the aquatic habitat, and the biodiversity of plants will document the relative health of the system.

Depending on the water rights determination, the park will either formally apply for the water rights or take measures to dismantle the dike/dam and block the diversion. If water rights are applied for, measures to maintain the reservoirs' structure should be included in the maintenance workload. A 404 Permit will be required if the reservoirs are removed, because the area now constitutes a wetland.

Development of a management plan will address future management requirements for either maintenance of the reservoir system or restoration of the area to pre-reservoir conditions. The plan will also synthesize the habitat data and recommend specific actions for corridor and bank restoration.

Implementing the plan is projected to require a large amount of funding, primarily because of the anticipated heavy equipment needs (reference PECO-N-015.000).

BUDGET AND FTEs

FUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
			Total:	0.0	0.0

UNFUNDED

Term	Source	Activity	Fund Type	Budget ($1000)	FTEs
Year 1		RES	O	5.0	0.5
		MON		30.0	0.0
			Subtotal:	35.0	0.5
Year 2		RES	O	20.0	0.0
		MON		10.0	0.0
			Subtotal:	30.0	0.0
			Total:	65.0	0.5

Compliance codes: EA (ENVIRONMENTAL ASSESSMENT)
Explanation: Applicable environmental assessment and other environmental/cultural compliance activities should be undertaken as part of the initial restoration feasibility assessment.